Ministry of
Northern Development
and Mines
Ontario

Ontario Mines and Minerals Symposium
Geoscience Research Seminar 1990

December 10-12, 1990

Abstracts

1990

91-06721/

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Printed in Ontario, Canada

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Parts of this publication may be quoted if credit is given. It is recommended that reference be made in the following form:

Armstrong, D.K. and Gorman, R.G. 1990. Geology and aggregate resources of the Moosonee area, northeastern Ontario; *in* Abstracts, Geoscience Research Seminar 1990, p.1.

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ABBREVIATIONS

COMDA	Canada–Ontario Mineral Development Agreement
GSC	Geological Survey of Canada
MDLB	Mineral Development and Lands Branch
MNDM	Ministry of Northern Development and Mines
OCRS	Ontario Centre for Remote Sensing, Ministry of Natural Resources
OGRG	Ontario Geoscience Research Grant
OGS	Ontario Geological Survey
ROM	Royal Ontario Museum

STRUCTURAL EVOLUTION OF THE MICHIPICOTEN (WAWA) GREENSTONE BELT, SUPERIOR PROVINCE: EVIDENCE FOR AN ARCHEAN FOLD AND THRUST BELT

Arias, Z.G., and H. Helmstaedt, Department of Geological Sciences, Queen's University, Kingston

Structural studies in the central part of the ca. 2.7 to 2.9-Ga Michipicoten greenstone belt suggest the presence of inverted regional folds (F2) that have refolded an overturned limb of a belt-scale recumbent nappe structure (F1). The nappe was also imbricated along thrust faults related to the D2 folding event.

Field observations show that the metasedimentary rocks in the central part of the belt unconformably or disconformably overly intermediate to mafic metavolcanic rocks, and represent the youngest rocks in the section. The depositional unconformity is structurally overturned up to 45 degrees. A major fault (Magpie River Fault, Corbiere Township) separates the overturned, southward-younging volcanic-sedimentary sequence from a geologically similar, overturned, northward-younging sequence of rocks. This configuration defines a regional, faulted, inverted syncline (F2). On the basis of kinematic analyses in fault zones along the regional F2 fold hinge and along some lithologic contacts, the faults are interpreted as south-verging thrusts. Repetition of rock units within the overturned limb of the nappe (F1) can be attributed to imbrication along the D2 thrust faults. Consequently, the youngest supracrustal rocks, formerly interpreted as a thick stratigraphic sequence of two volcanic cycles, represent a single lithologic package that was highly deformed and thickened by structural stacking. On the local scale, in volcanic and sedimentary rocks of the central part of the belt, the regional strike of the rock units is approximately parallel to the axial surfaces of prominent F2 folds. The limbs of these folds are typically sheared off parallel to their axial surfaces along F2-related imbricate thrusts. Younging reversals along the F2 axial surfaces (S2) indicate the presence of earlier folds (F1), only locally associated with an S1 cleavage. These folds may represent minor folds in the overturned limb of the recumbent nappe structure.

D2 folds and related thrusts are affected by east-northeast-striking shear zones (D3) which, depending on the strike of the D2 thrusts, have either dextrally offset or reactivated the thrusts as oblique-slip faults. The D3 shear zones are similar to gold-hosting shear zones studied in the east-central part of the belt (Goudreau-Lochalsh). All earlier structures are overprinted by a crenulation cleavage (S4) which consistently strikes northeastward.

The early regional nappe structure, imbricate thrusts, and the complex fold overprint in the central part of the Michipicoten greenstone belt are comparable to structures in Phanerozoic orogenic belts involving horizontal shortening in convergent plate settings.

GEOLOGY AND AGGREGATE RESOURCES OF THE MOOSONEE AREA, NORTHEASTERN ONTARIO

D. K. Armstrong and R. G. Gorman, Engineering and Terrain Geology Section, Ontario Geological Survey

During the summer of 1990, the Ontario Geological Survey undertook an investigation of the aggregate resources of the Moosonee area. This project was designed to delineate current aggregate sources, identify new sources, and systematically sample all potential aggregate sources in the study area for quality testing. Results of this project will enable the evaluation of aggregate resources for the area and will aid in land use planning decisions. The area studied includes Moose and Horden geographic townships, river bars and islands in the Moose River between the mouth of the Kwetabohigan River and James Bay, and the Rabbit Ridge area, east of the Moose River.

The Moosonee area is located in the eastern part of the Moose River sedimentary basin and is underlain by more than 140 m of Paleozoic strata. The youngest Paleozoic unit in the area is the Middle Devonian Kwataboahegan Formation. Fossiliferous limestones and dolostones of this formation outcrop along the Kwetabohigan River and are exposed in the Labelle Quarry and in the floor of sand and gravel pits at Rabbit Ridge.

Quaternary glaciation in the study area is evidenced by striated bedrock surfaces and a thin till deposit exposed in the bank of the Kwetabohigan River (glacial deposits are more significant south of the study area). Subsequent to glaciation, the area was inundated by the Tyrrell Sea and marine clays (up to 30 m thick at Moosonee) were deposited. Raised beach deposits, consisting of material ranging from silt to coarse gravel, were developed on the clays as the sea receded. Sand and gravel bars were deposited by the Moose River as it progressively incised the clay plain.

A wide range of crushed stone products have been produced from the Kwataboahegan Formation in the Labelle Quarry. The most significant sand and gravel source in the Moosonee area is the raised beaches of the Rabbit Ridge area. Material in these beaches ranges from sand to coarse crushable gravel. Medium to coarse sand and fine gravel is dredged from river bars located between Moosonee and Moose Factory Island. Aggregate quality testing of samples from these and other potential sources in the study area is currently being conducted by the Soils and Aggregates Section of the Ontario Ministry of Transportation.

QUATERNARY GEOLOGY OF ONTARIO.

Barnett, P.J., Engineering and Terrain Geology Section, Ontario Geological Survey.

Ontario was completely covered by the Laurentide Ice Sheet for the last time 20,000 years ago. The margin of the Laurentide Ice Sheet was extremely lobate in the Great Lakes region, responding to regional topographical conditions as well as the presence of water ponded in contact with the glacier margin. Proglacial ice-contact lakes formed and disappeared with fluctuations of the ice margin. The level of ponding was controlled by the lowest available outlet within the basin. Glaciolacustrine sediments of gravel, sand, silt, and clay were deposited within a series of proglacial lakes that followed the ice margin northward.

Advances over glacial lake (glaciolacustrine) sediments generally produced fine-grained tills around the basins of the Great Lakes. Fine-grained till also occurs in the Rainy River area (glacial Lake Agassiz basin) and in the area around Hudson Bay where glaciolacustrine sediments were also overridden.

The record of events that took place during the Quaternary Period in Ontario have been summarized in a manuscript entitled "Quaternary Geology of Ontario" published in the "Geology of Ontario" volume. Several stages of the deglaciation of Ontario are depicted in a sequence of illustrations.

GEOLOGY OF THE CASUMMIT LAKE AREA

G.P. Beakhouse, Precambrian Geology Section, Ontario Geological Survey

The Casummit Lake area is located at the north end of the Birch-Uchi greenstone belt. All of the bedrock in the area is inferred to be of Archean age.

The metamorphosed supracrustal rocks of the map-area can be subdivided into a northern mafic association (NMA) and a southern heterolithic association (SHA). This subdivision may have significance for mineral exploration in as much as many of the known gold occurrences lie within 500 metres of the NMA-SHA transition.

The NMA consists almost entirely (>95%) of massive, pillowed and auto-brecciated mafic flows. Minor chert-magnetite ironstone interflow units that are rarely more than 1 meter thick are common. Minor intermediate fragmental metavolcanic rocks and clastic metasedimentary rocks are interbedded with the metabasalt near the transition between the two associations.

The SHA consists predominantly of intermediate tuff, lapilli-tuff and tuff-breccia but also contains significant amounts of mafic flows (~10-15%) and felsic pyroclastic deposits, flows and massive porphyries (~5%) as well as clastic metasedimentary rocks (~5%) and minor chert and magnetite ironstone.

The supracrustal rocks have been intruded by; (1) large external granitoid complexes which bound the greenstone belt, the emplacement of which is responsible for much of the deformation, (2) the Mink Lake granodiorite stock which hosts a disseminated molybdenite deposit, and (3) minor gabbroic to dioritic mafic plutons.

A moderate to strong tectonic fabric ($\approx D_2$ in the previously mapped Birch Lake area to the south) is parallel to bedding throughout most of the map-area. D_1 fabrics have not been observed in the present area. Bedding and D_2 structures are folded about axes plunging steeply north with the attendant development of an axial planar fabric and conjugate shears (D_3). The result is a complex geometrical arrangement of structures which cannot be consistently differentiated.

Gold mineralization is spatially associated with lithologic contacts, especially the NMA-SHA transition. This is interpreted to be due to the presence of structures (intense fabric, shears) which developed preferentially near lithological contacts and served to focus fluid flow responsible for alteration and gold mineralization. The geometry of veins is controlled by both D_2 and D_3 structures, and therefore almost any orientation of veins is to be expected within these favorable zones.

STRATIGRAPHY AND FACIES OF THE DUNDEE FORMATION, SOUTHWESTERN ONTARIO

Birchard, M.C. and Risk, M.J., McMaster University Geology Department, Hamilton, Ontario.

The Middle Devonian Dundee Limestones of Southwestern Ontario accumulated in the Michigan and Appalachian Basins, with deposition in part being controlled by the proximity to the Findlay and Algonquin arches. Six lithofacies were recognized in the Dundee Formation during detailed core and outcrop studies. Stratigraphic relations indicate that, prior to deposition of Dundee carbonates, a major regression exposed underlying Detroit River sediments adjacent to the arches. Subsequent transgression deposited reworked sands and shallow shelf, bioclastic limestones in most areas of the adjoining basins while in westernmost regions of the Appalachian Basin Columbus Formation sediments were accumulating adjacent to the Findlay Arch.

Transgression became interrupted during middle Dundee time and a thick unit of lagoonal muds was deposited in the Appalachian Basin. A regionally well-developed firmground capping these mudstones indicates that a significant episode of non-deposition ensued. The equivalents of these muds in the Michigan Basin are pulses of coarse, reworked grainstones and rudstones indicating that substrates there were shallower and above wave base. Evidence of subsequent renewed transgression is preserved as middle to outer shelf moderately fossiliferous mudstones and wackestones overlying shallow shelf facies.

Well-developed traceable 'packages' of firmgrounds commonly occur in middle to outer shelf facies and record step-like transgressive conditions with relative sea level rise interrupted by episodes of stillstand and non-deposition. These firmgrounds developed adjacent to paleotopographic highs and have distributions similar to hardgrounds documented in modern, shallow epicontinental seas of the Persian Gulf. Uppermost Dundee strata in the Appalachian Basin suggest a final transgressive episode with deposition of deep water argillaceous mudstones; however, upper Dundee strata in the Michigan Basin document a period of sea level stillstand, winnowing and reworking.

RECENT MINING AND EXPLORATION DEVELOPMENTS IN THE SUDBURY AREA - 1990

Cosec, Michael, Sudbury Resident Geologist's District

Mining and exploration activities in the Sudbury area remained relatively healthy in 1990, as reflected by the sound price of nickel throughout the year.

Inco Limited operated nine underground mines, two open-pit mines, three mills, one smelter, two refineries, and one strip rolling mill. Annual nickel production was thought to be approximately 210 million pounds. Expansion of the Clarabelle mill continued, as did development at the McCreedy East, Lower Coleman, and Craig mines.

Falconbridge Limited had production from five underground and one open-pit mine yielding approximately 70 million pounds of nickel. Development continued at the Strathcona mine, but operations ceased at the East mine. Exploration and shaft-sinking at the T. L. Exploration shaft reached 1450 metres.

Orofino Resources Limited completed milling stockpiled gold ore from the Scadding mine.

Several varieties of building stone, as well as silica and dolomite were also produced.

Inco Limited and Falconbridge Limited conducted surface exploration on their patented claims in the Sudbury area, B.P. Canada Incorporated commenced extensive exploration on a gabbro-anorthosite intrusion in the Agnew Lake area, and junior mining companies were active in the Benny greenstone belt and east of Wanapitei Lake. Falconbridge Limited staked an extensive group of claims covering the southwest portion of the Temagami magnetic anomaly.

LITHOPROBE seismic reflection and high resolution geophysical surveys were completed across the Sudbury structure. A mineral occurrence study and building stone inventory were completed through COMDA funding. D. Peck of Laurentian University commenced a post-doctoral investigation of the mineral potential of rocks in the East Bull Lake area.

DEFORMATION IN THE EASTERN SOUTH RANGE DEFORMATION ZONE, SUDBURY STRUCTURE

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The South Range Deformation Zone of the Sudbury Structure is a 2-6 km wide, NE-SW striking ductile deformation zone. It deformed the Sudbury Igneous Complex and the Onaping Formation under greenschist to lower ampibolite metamorphic conditions. Previous work has concentrated on the central and western parts of the deformation zone and it was concluded that:

1) The South Range Deformation Zone is a south-over-north, ductile thrust zone which dips 40-45 degrees to the southeast.
2) The estimated minimum net displacement in the central South Range Deformation Zone exceeds 8 km, assuming that the ductile strain was heterogeneous simple shear, and that the abundant microscale discontinuous crenulation surfaces are parallel to the shear-zone boundary.
3) The South Range Deformation Zone leaves the Sudbury Structure through its southwestern closure.

Current work in the eastern extension of the South Range Deformation Zone has established that:

i) The eastern South Range Deformation Zone strikes E-W to ESE-WNW and the change in strike occurs at Whitson Lake.
ii) The eastern South Range Deformation Zone is ~4 km wide and has affected mainly rocks of the Onaping Formation. and the Granopyre. The gabbroic and noritic rocks of the Igneous Complex were largely unaffected by the deformation zone.
iii) Abundant cm-wide anastamosing "lozenge shears" dip steeply to .e SSW (mean lozenge spacing of 1/2 metre), and abundant microscale discontinuous crenulation surfaces are shallowly inclined in the same direction as the lozenge shears within the Granophyre. The lozenge shears recorded a large component of coaxial strain, which contradicts the hypothesis of heterogeneous simple shearing, at least in the eastern South Range Deformation Zone. The deformation zone is, therefore, interpreted as a flattened reverse-shear zone, whereby the component of non-coaxial strain produced the abundant south-over-north crenulation surfaces.

4) The eastern South Range Deformation Zone dips 60-70 degrees SSW, according to the aforementioned model of a flattened reverse-shear zone.

HIGH-RESOLUTION MAGNETIC-SUSCEPTIBILITY PROBE FOR MINERAL-EXPLORATION BOREHOLES: A PROGRESS REPORT

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A borehole logging probe has been developed to detect small-scale magnetic features by recording variations in the probe's response as a function of its axial position. The objective is to determine the geologic and mineral-exploration significance of variations in susceptibility on a scale of millimeters to centimeters. The magnetic equivalent of a three-point measurement can be used to determine orientation of planar magnetic contrasts intersected by the borehole, a capability which is of interest in detecting the magnetic signatures of structural indicators.

The probe measures magnetic field anomalies (residual field detected by miniature Hall-effect sensors) corresponding to the ease with which the wall rock is magnetized in the presence of an applied magnetic field supplied by two powerful permanent magnets. In general, rocks are only slightly magnetic (paramagnetic) so the residual tends to be quite small in comparison to the applied field. The design phase was carried out with the Infolytica finite-element modelling program. It involved adjustment of size, shape, position and composition of the probe's internal components to maximize the ratio of residual field to applied field. Miniature Hall-effect sensors are used to detect the residual field.

Laboratory tests have been carried out with computerized data acquisition and a linear scanning apparatus to simulate the effects of simple situations under controlled conditions. This arrangement is also suitable for systematic scanning of drill core. The drillhole probe for field use is the same unit housed in a waterproof case, with the addition of inclinometers for orientation (non-vertical holes only). Examples are shown to illustrate the nature of high-resolution magnetic susceptibility variations and their potential utility in characterizing geologic environments.

REGIONAL GEOCHEMICAL SURVEY: HANES LAKE SHEET

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The Hanes Lake Regional Geochemical map is the third in a new series of geochemical maps now being prepared by the Ontario Geological Survey.

The Hanes Lake map is the second to be released in the Batchawana greenstone belt area. This map area lies to the east of the Trout Lake Sheet released in December 1989 and includes the east end of the belt including the Goulais Iron range which shows clearly on the new map.

The Hanes Lake map includes some significant geochemical patterns from the viewpoint of mineral exploration. One pattern is a cluster of above background W values and the other is a similar cluster of Mo values . Both are associated with areas of felsic intrusions. In another part of the map sheet a small geochemical province pattern for several elements is associated with multiple samples collected from the same lake.

A CENTURY OF INVESTIGATING ONTARIO GEOLOGY

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In 1991, the Ontario government will mark 100 years of encouraging the orderly development and production of the province's mineral resources. May 5, 1891 marked the appointment of Archibald Blue to initiate a provincial "Bureau of Mines". The Bureau, by a series of reorganizations, has evolved to become today's Mines and Minerals Division of the Ministry of Northern Development and Mines.

Beginning with three staff, the Bureau of Mines gradually expanded its operations and staffing until superceded, effective November 24, 1919, by a Department of Mines. Today's Mines and Minerals Division of the Ministry of Northern Development and Mines is the result of considerable growth in the 1960s and 1970s as major programs were undertaken, and of administrative changes in the 1970s and 1980s.

A number of activities and events are planned to mark this centennial, among them, the Ontario Geological Survey's release of a comprehensive review of the geology of Ontario. Created by a team involving personnel of all operating sections of the Survey and some regional staff, it is composed of a map series at 1:1,000,000 and text. As the first compilation of provincial geology since the advent of high-precision radiometric ages, geochemical analyses, and computerized geophysics; many new relationships will be described.

PGE DEPOSITS IN THE COLDWELL COMPLEX: EXAMPLES OF MODIFIED FLOOD BASALT RELATED SULPHIDES

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The MacRae occurrence and the Marathon deposit are located within and at the intrusive margin, respectively, of the Coldwell alkaline complex, near Marathon, Ontario. The initial sulphide composition of the CAC deposits was similar to that of flood basalt related intrusions such as the Crystal Lake Gabbro and the Duluth complex. However, ore specimens are enriched in Cu and Pd with respect to Ni and Ir when compared to the latter deposits, and therefore processes of PGE fractionation during deposition are proposed. At the MacRae occurrence petrographic and geochemical data support a model whereby an evolved felsic melt intruded the partially crystallized Geordie Lake Gabbro. Disseminated sulphides are included within the secondary plagioclase and clinopyroxene overgrowths, but higher concentrations of sulphide are associated with interstitial amphibole. The abundance of, and interelement ratios for, the PGE in weakly mineralized samples are constant, but are decoupled from Ir and Ni with increasing sulphides, Pd and Cu. It is proposed that sulphides were introduced by the evolved felsic melt, but were concentrated by related hydrothermal processes.

The Marathon deposit is hosted by the Two Duck Lake Gabbro which intruded close to the contact between an older gabbro and Archean country rock. The composition of sulphides at the Marathon deposit varies systematically, regardless of chalcopyrite:pyrrhotite ratios or associated hydrous or non-hydrous silicate assemblages. There is a strong exponential correlation between Pd and the other metals, but there is only a weak linear correlation between S and the PGEs (r=.60 to .65). Pd/Ni, Pd/Ir and Pd/Rh increase with increasing Pd, but Pd/Pt, Pd/Au and Pd/Cu are relatively constant. These observations are inconsistent with the extraction of a Cu-rich sulphide melt from a previously formed magmatic sulphide deposit and can only be accounted for by fractionation subsequent to the evolution of a sulphide melt from the TDL magma. A proposed model involves the strong depletion of Ni and Ir and slight enrichment of Pt, Pd and Cu by minor pyrrhotite crystallization from a mobile interstitial sulphide melt. The sulphide melt probably migrated in response to silicate crystallization and gravity to form the mineralized zone.

LEAD ISOTOPE INVESTIGATIONS BEARING ON THE SOURCE OF GOLD AND OTHER MINERALIZATION IN THE RED LAKE AREA

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The problems of timing and source of gold and sulphide mineralization have been addressed in the Red Lake area from 300 Pb isotope analyses on >250 samples of sulphides, oxides, gold and potential source rocks.

Sulphides from the Campbell/Dickenson mines give an apparent Pb-Pb age of 3040 $\pm$ 60 Ma comparable to a mafic host rock age of 3070 $\pm$ 30 Ma and felsic rocks dating 2980 $\pm$ 40 Ma. These Pb-Pb ages compare with precise U-Pb zircon ages ranging from 2964 to 2992 Ma in the felsic metavolcanics. A somewhat younger Pb-Pb age of 2865 $\pm$ 10 Ma is obtained from minor mineralization from the west part of the Red Lake greenstone belt, while sulphides and gold from McFinley, Cochenour Willans and Abino mines gives an apparent Pb-Pb age of 2810 $\pm$ 30 Ma.

Sulphides from deposits in the Flat Lake-Howey Bay deformation zone exhibit variable isotopic patterns that contrast with the composition and age of their host rocks. Madsen and Starratt-Olsen sulphides hosted by old metavolcanics have apparent ages of 2800 Ma. In contrast, Buffalo and Hasaga sulphides hosted by late felsic intrusions have poorly defined apparent ages of 2900 $\pm$ 100 Ma.

A combined age of 2830 $\pm$ 20 Ma for mafic metavolcanics and metasediments from McKenzie Island agrees with a zircon U-Pb age from a felsic tuff on the same island.

Younger sulphide mineralization from across the greenstone belt with uniform $^{206}Pb/Pb^{204}$ values of 13.4 to 13.5 give calculated "model ages" of 2700 to 2730 Ma.

Magnetites from late widespread felsic intrusions yield young ages of 2660 $\pm$ 10 Ma, precluding a genetic connection of the felsic intrusions with gold mineralization.

The Pb isotope data from gold samples reveal complex isotope patterns. Part of the lead had a source with unusually high $^{207}Pb/Pb^{204}$ values indicating either a highly evolved 3 Ga source or maturation of Pb prior to extraction in a 2.7 Ga mineralizing event.

The linearity of Pb isotope data for old deposits precludes a single late gold event. Gold may be associated with all three episodes of volcanism as well as plutonism.

PALEOMAGNETIC CONSTRAINTS ON THE TIMING OF MINERALIZATION IN SHEAR ZONES

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Paleomagnetism is unique in its ability to simultaneously provide both structural and temporal information. We have carried out thermal and alternating field demagnetization studies on a suite of gabbro, metabasalt and granodiorite samples from the Meen Lake-Dempster Lake greenstone belt to explore the idea that paleomagnetism can be used to unravel the strain history of a region and to date ore-forming hydrothermal activity. Characteristic magnetizations have been recovered from the 2.74 Ga. Dobie Lake Batholith (Dec.=182, Inc.=-66, K=56, Alpha95=12) and Kawashe Lake Gabbro (Dec.=258, Inc.=-73, K=19, Alpha95=12).

Although these magnetizations are about the same age, they differ in direction by at least 25 degrees. This is evidence of post-emplacement rotation of the Kawashe Lake Gabbro relative to the Dobie Lake Batholith. Similar steep positive magnetizations have been recovered from the 2.72 Ga Kawashe Lake Stock and the 2.69 Ga Graniteboss Lake Stock. The pole positions implied by these magnetizations agree with other 2.7 Ga paleomagnetic poles from the Abitibi subprovince. The rotation of the Kawashe Lake Gabbro therefore must have occurred prior to the emplacement of these intrusions. The timing of the deformation is constrained between 2.74 and 2.72 Ga.

All of the new paleomagnetic poles from the Uchi subprovince lie well away from the swathe of Abitibi subprovince poles that until recently were thought to provide an Archean APWP for use in dating.

Gabbro samples from outcrops that have been locally sheared show that the steep, reversed magnetization is disturbed in the shear zones but it survives in the more massive rocks. This magnetization therefore must predate the shearing. A post-shearing magnetization would remagnetize both sheared and massive parts of an outcrop. This observation provides a powerful tool for dating mineralizations. If a characteristic magnetization can be associated with a mineralized zone, a comparison of the magnetizations carried by sheared and massive samples can provide a means to discriminate between syngenetic and epigenetic mineralization mechanisms.

Paleomagnetism can thus provide information on the timing of both deformation and mineralization that may be useful in planning exploration programs.

OGS AIRBORNE SURVEY PROGRESS: 1975-1990

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In an effort to stimulate activity in the mining exploration community the government of Ontario has been involved with airborne geophysical survey in the province since 1975. There have been many joint federal-provincial surveys conducted since then, but in this review, a history of the provincial government's small scale-higher resolution electromagnetic (time/frequency domain) and magnetic airborne surveys, conducted since 1975, will be highlighted.

By the end of 1991 there will have been twenty eight airborne surveys carried out by the Ontario Geological Survey (OGS) resulting in more than 430,000 line kilometers of airborne data collected over high mineral potential areas of the province. Many advances in airborne survey technology and geophysical interpretation techniques have required the OGS to constantly update and create new and innovative survey criteria and end-user products.

A synoptic review of the OGS's airborne survey program is presented with a special emphasis on: 1) an overall summary of survey progress, 2) a statistical treatment of survey work, 3) a review of client products such as maps, microfiche and digital data, and 4) a review of benefits provided to the exploration industry and earth science community. Five airborne surveys completed in 1990 and four new airborne surveys underway for 1991 will be outlined and discussed briefly. These surveys complete the current funding initiative (five year Airborne Geophysical Survey Program) supported by the Northern Development Fund.

SUPRACRUSTAL ASSEMBLAGES AND STRUCTURE OF THE LATE ARCHEAN SOUTHERN ABITIBI GREENSTONE BELT NEAR LARDER LAKE

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Structural and stratigraphic relationships of supracrustal assemblages remain outstanding problems in the understanding of the geological history and mineralization of the Abitibi Greenstone Belt. During 1990, the metavolcanic-dominated McElroy and Larder Lake assemblages and the metasedimentary-dominated Hearst and Timiskaming assemblages were studied. The homoclinal NE-facing McElroy assemblage is dominated by massive mafic rocks, pillowed basalt, plagioclase-glomerophric units, ultramafic rocks, and felsic fragmental rocks. The multiply folded and faulted Larder Lake assemblage consists mostly of pillowed mafic rocks and komatiite. The assemblage does not contain plagioclase-glomerophyric units and contains only minor felsic metavolcanic units. These two assemblages, and their contrasting structural styles, are separated by the south-side-up (?), steeply dipping, Lincoln-Nipissing shear zone. This shear zone also defines the southern limit of turbidite facies metasedimentary rocks of the Hearst assemblage which rests stratigraphically above the earlier-deformed Larder Lake assemblage. Detrital sources for the Hearst assemblage included the Skead and McElroy and/or Larder Lake assemblages. Alluvial-fluvial facies metasedimentary rocks of the Timiskaming assemblage lie unconformably above the earlier-deformed metavolcanic Kinojevis assemblage and are overthrust by the more southerly Larder Lake and Hearst assemblages along the Cadillac-Larder shear zone. Source material, sedimentary facies, and the presence (Timiskaming) or absence (Hearst) of alkalic metavolcanic rocks suggests two scenarios in relating the metasedimentary assemblages: (1) the Timiskaming and Hearst assemblages could represent deposits of different, late-tectonic basins; 2) the Hearst assemblage could represent early and distal deposits, whilst the Timiskaming assemblage could represent later and proximal deposits of the same basin. In either case the assemblages were later juxtaposed.

Emplacement of the Round Lake Batholith deflected metavolcanic units prior to deposition of the metasedimentary assemblages. NW-striking folds and faults post-dated deposition of the Hearst assemblage and the emplacement of at least some alkaline intrusions (e.g. McElroy Stock). NE-striking folds and faults and finally N-striking (NNW to NNE) folds and faults post-dated the NW-striking structures. In post-Archean time, NNE-striking structures in the Proterozoic Huronian Supergroup formed and may reflect reactivation of underlying Archean basement structure.

Most large gold deposits in the area are located near the intersection of late NE-striking and/or ENE-striking shear zones with the Cadillac-Larder shear zone. Away from this shear zone, smaller gold deposits are located near late ENE-, NE-, NNE-, and NW-striking shear zones.

GEOLOGY OF THE WHISKEY LAKE GREENSTONE BELT, DISTRICTS OF ALGOMA AND SUDBURY

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The Whiskey Lake Greenstone Belt is a 40 km long arcuate, belt centred approximately 25 km west of Elliot Lake. It is bounded to the north by Proterozoic sedimentary rocks of the Quirke Syncline, and to the south and east by granitoid rocks of Archean and Proterozoic age.

The greenstone belt consists of komatiitic, tholeiitic, and calc-alkalic metavolcanic rocks cut by metamorphosed, subvolcanic, calc-alkalic, porphyritic dikes and sills. In places, interflow metasedimentary rocks, that include banded iron formation, chert, wacke and siltstone, occur with the metavolcanic rocks. The calc-alkalic rocks represent a mineralized, felsic volcanic domal complex that was built on a tholeiitic basalt platform. Strong silicification, epidotization, sulphidization and quartz-veining is present in the domal complex.

The Archean granitoid rocks are mainly gneissic to massive tonalites, intruded by trondhjemites, in turn intruded by fine-grained to megacrystic granodiorite and quartz monzonite.

Proterozoic rocks of the Huronian Supergroup unconformably overlie the Archean rocks. The basal rocks of the Supergroup comprise tholeiitic volcanic rocks of the Thessalon Formation underlain in places by a thin boulder conglomerate. The uranium-bearing Matinenda Formation of the Elliot Lake Group overlies the Thessalon Formation.

Archean to Proterozoic, mostly post-Huronian, mafic intrusive rock occurs in the area as gabbro sills and diabase dikes

Archean deformation events include folding and faulting prior to, during and subsequent to the emplacement of the granitoid rocks. The last event allowed for the formation of deeply eroded scarps in the Proterozoic topgraphy and their subsequent filling by Proterozoic Thesselon volcanic rocks on which the remaining Huronian Supergroup was deposited. Proterozoic deformation includes folding, thrust faulting and normal faulting that occurred concurrent with late mafic magmatic events.

Favourable geological features for base, precious and platinoid metal exploration include the presence of a felsic volcanic centre, sulphide-bearing iron formation and mafic intrusive rocks, altered rocks along shear zones, and detrital sulphide-bearing conglomerates in the Huronian Supergroup.

PGE AT SUDBURY: ITS CONCENTRATION BY SULPHIDE LIQUID FRACTIONATION

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Platinum-group elements (PGE) occur throughout the ore zones of the Strathcona deposit on the North Range of the Sudbury Complex, but individual PGE are fractionated from each other. Pt, Pd and Au increase progressively, along with Cu, away from the basal contact of the Sublayer norite towards the footwall, and Rh, Ru, Ir and Os show the reverse trend.

The Deep Copper Zone, which is the farthest from the contact in the deposit, falls at one extremity of the compositional variation. It is marked by the highest abundances of PGE and ratios of Cu/(Cu+Ni) and (Pt+Pd)/(Os+Ir+Ru). PGE are not distributed uniformly within this zone. Generally, Pt and Pd increase in areas where Os, Ir, Ru and Rh decrease in abundance. This zonation is visible across the vein system as a whole with Pt, Pd increasing and Os, Ir, Ru, Rh decreasing away from the contact of SIC. The same trend of increasing Pt and Pd is also observed on passing from the main veins (>20 cm) to some small branching veins (<20 cm), which are usually associated with hydrothermal minerals and have more intensive alteration than the main veins, and also at the terminations of the veins.

PGE analysis of individual minerals (by AMS) indicate that sulfide minerals, such as pentlandite, chalcopyrite, millerite, cubanite, and bornite contain much lower Pt, Au and Ir than the ore as a whole (ppb vs ppm levels respectively) whereas magnetite contains slightly higher Ir than the bulk ores.

It is suggested that the fractional crystallization of sulfide liquid followed by hydrothermal fluids during the closing stages of crystallization can account for the observations: The early crystallization of monosulfide solid solution and magnetite concentrated Fe, Co, Ru, Rh, Ir and Os, and led to an enrichment in Cu, Pt, Pd and Au in the residual sulfide liquid. The progressive expulsion of the fractionated liquid into the footwall during its cooling give rise to the observed compositional variations in the different zones.

GEOCHEMICAL TRENDS AFFECTING OVERBURDEN EXPLORATION IN THE MATHESON AREA

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Between 1984 and 1989, the Ontario Geological Survey completed a regional overburden sampling and geochemistry program in the Black River-Matheson (BRiM) area of northeastern Ontario. In areas of shallow overburden, 282 surface till samples were collected from backhoe trenches. In areas of thicker drift, 1456 overburden samples were collected from 225 rotasonic drill holes.

Drill holes intersected a complex Quaternary stratigraphy consisting of from bottom to top: older tills and associated sediments; Owl Creek beds; Matheson Till; and Barlow-Ojibway glaciolacustrine sediments. The Owl Creek beds consist of organic-rich sediments deposited during a non-glacial interval and are a readily identifiable marker horizon in the region. Matheson Till, the youngest till sheet in the area, was deposited during the late Wisconsinan by ice that initially flowed southwestward and finally southeastward across the area. All surface till samples collected were from Matheson Till.

Surface samples of Matheson Till have been affected by oxidation and weathering as compared to subsurface samples collected from drill holes. This is evidenced by a very low matrix carbonate content, absence of sulphide grains in the non-magnetic heavy mineral concentrate (HMC) and elevated concentrations of Cu, Ni and Zn in the fine (<0.063 mm) fraction as compared to the HMC. Therefore, for surface till sampling, the fine fraction in addition to the HMC should be used for gold and base metal exploration.

Regional dispersal trends are readily discernable for surface samples of Matheson Till. Major oxides, non-magnetic heavy minerals and pebble lithologies display southeastward decreases in abundance and reflect changes in bedrock lithologies. Trace element geochemistry and gold grain abundances display local dispersal trends related to bedrock mineralization. Five areas of interest have been identified based on their anomalous concentrations of Au, Cu, Co, Ni and Zn. Due to the variable distribution Au in the HMC and fine fractions, both fractions should be used for gold exploration.

Kimberlite indicator minerals recovered from overburden samples indicate the potential presence of kimberlite pipes within, or immediately north of, the eastern portion of the study area.

DEFORMATION HISTORY OF THE MATACHEWAN AREA: IMPLICATIONS FOR GOLD EXPLORATION

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Structural study of the Matachewan area indicates five major Archean deformational events, followed by a post-Gowganda deformation in which major faults in the Archean basement were reactivated.

The first Archean deformation event resulted in folds without cleavage. These folds are not found in the Timiskaming Group. The second deformation formed an aureole of strong L-S fabric around the Round Lake batholith as it rose diapirically in a solid or semi-solid state. The third deformational event resulted in fault juxtaposition of Timiskaming and volcanic rocks (commonly ultramafic), extensive carbonatization and development of ESE-WNW trending "banded cleavage". The fourth Archean deformational event resulted in the development of the Kirkland-Larder Lake break and ENE-WSW chloritic crenulation cleavage. The final Archean deformation formed open folds with axes plunging steeply to the northeast and southwest.

Following erosion and deposition of the Gowganda Formation, cleavageless, upright, gentle folds with NE-SW trending axes formed in the Gowganda, and Archean fault zones were reactivated. Open folds, with a variably developed, subvertical pressure solution cleavage and thin quartz veinlets formed in the Gowganda sedimentary rocks overlying these reactivated faults.

At least one period of post-Archean extension has affected the Gowganda Fm.. A series of north-south trending normal faults (eg. Mistinikon Lake Fault) and northwest-southeast normal faults (eg. Cross Lake Fault) cut the Huronian rocks. The northwest trending fault set offsets rocks of Middle Silurian age. North-northeast striking, vertical quartz veins with strike lengths in the order of 100's of feet are located in the Gowganda sediments, within 1 kilometre of the Mistinikon Lake Fault.

Post-Archean structures in the Gowganda reflect Archean structures, and thus, provide a means of prospecting for Archean mineralization in areas of Proterozoic cover. The location of Archean deformation zones beneath the Proterozoic rocks is indicated by folds; steep bedding, regular quartz veinlets and/or the presence of cleavage in the Gowganda Fm.. Trace element analysis of the quartz veinlets can then be used to identify gold-anomalous areas which may reflect mineralization in the underlying basement rocks. Analysis of vein material from the north-northeast veins associated with normal faulting might also be of use in identifying areas overlying mineralization.

QUALITY CONTROL FOR RARE-EARTH ELEMENTS IN GEOLOGICAL MATERIALS: COMPARISON OF XRF AND ICP-MS ZIRCONIUM DETERMINATIONS

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The rare earth elements (REE) are geologically important as they are economically and petrogenetically significant. However, due to the low abundances of REE in geological materials (0.001 - 10 ppm REE), the necessary precision and accuracy demanded by geologists cannot be met by solid sampling techniques such as X-ray fluorescence. Inductively coupled plasma-mass spectrometry (ICP-MS) has appropriate detection limits, but it requires that the sample be introduced as a liquid.

The insoluble nature of some REE-rich minerals, particularly zircon, results in a systematic low bias in REE determinations when conventional acid-based dissolution procedures are used. An alternative, reliable sample preparation procedure, lithium metaborate fusion followed by acid dissolution, is expensive and time consuming.

The Geoscience Laboratories compares Zr determinations done by XRF and ICP-MS to identify those samples in which a low bias occurs due to the incomplete dissolution of zircon in mineral acids. After consultation with the geologist as to the end-use of the data, identified samples can be reprepared by the acid fusion preparation technique can be used. This procedure results in precise, accurate data and the cost-effective use of resources within the Laboratories.

GEOLOGY OF THE SAVANT LAKE AREA

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The Savant Lake greenstone belt (SLGB) comprises dominantly metavolcanic and metasedimentary rocks and forms part of the Wabigoon Subprovince of the Superior Province of northwestern Ontario. Metavolcanic rocks include tholeiitic basalts of the Jutten volcanic group (JVG); intermediate pyroclastic rocks and flows of the Whimbrel Lake formation; and felsic to intermediate flows and pyroclastic rocks of the Handy Lake volcanic group (HLVG). Metasedimentary units include conglomeratic wackes and quartz arenites of the Jutten sedimentary sequence; polymictic conglomerates of the Savant Narrows formation; and feldspathic wackes, lithic wackes and magnetite +/- chert ironstone of the Savant sedimentary group. The SLGB is intruded by plutons of felsic to intermediate composition, and is bordered by foliated and gneissic granitoid rocks.

Two episodes of folding appear to have affected much of the SLGB; including the JVG, which historically has been interpreted as a northwest-facing sequence more than 10 000 m thick. Evidence of two folding events is provided by: 1) opposing structural facing directions throughout the supracrustal sequences; 2) outcrop-scale, refolded fold patterns; and 3) folds with axial surfaces and respective axial planar cleavages which strike both northward and eastward. Planar fabrics throughout the SLGB are generally associated with these two folding events, except in areas of increased strain intensity related to shearing.

The most prominent and laterally continuous zone of ductile deformation is the Kashaweogama Lake shear zone (KLSZ), where highly tectonized and altered rocks are exposed at least 45 km from Schist Lake in the west to the west-central shore of Savant Lake. The KLSZ strikes 070° to 080°, dips steeply northward, and possesses steep, down-dip mineral lineations that reveal south-side-down, dip-slip movement. Variably tectonized and altered (iron carbonate) rocks are observed at numerous other localities throughout the SLGB.

Mineral exploration in the area is for mesothermal gold and volcanogenic massive sulphide deposits. Gold is spatially associated with 070°- to 090°- striking shear zones with associated carbonate +\- silica alteration and quartz vein development (e.g., the KLSZ). Base metal exploration continues to focus on volcanic rocks of the HLVG in the southwest part of the SLGB. Hydrothermal alteration associated with base metal mineralization is indicated by the presence of secondary amphibole and aluminosilicate minerals such as staurolite, kyanite, andalusite and sillimanite.

STRUCTURAL GEOLOGY OF THE WESTERN BEARDMORE-GERALDTON BELT

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The Beardmore gold camp, within Eva and Summers townships, is at the western end of the Beardmore-Geraldton Belt (BGB), a transitional supracrustal sequence between the Quetico and Wabigoon subprovinces of northwestern Ontario. The BGB, formerly known as the Sturgeon River gold belt, consists of three metavolcanic and three clastic-rich metasedimentary sequences, each of which is narrow (≤10 km thick), trends eastward and is subparallel to the strike of the main belt. Gold production from the BGB exceeded 4 million ounces, nearly ¼ of which was produced from the Beardmore camp. Recent discoveries of fault-zone-hosted gold mineralization elsewhere in the BGB has lead, in general, to a re-evaluation of the BGB and specifically, to a detailed litho-structural re-mapping of Eva and Summers townships.

A proximal volcanic facies, characterized by rapid variations in rock type, was delineated in north-central Summers Township. Here, tuffs are interfingered with coarse metavolcanic fragmental rocks. Felsic fragments, some pumiceous, are conspicuous within an assemblage of fine lapilli-sized mafic to intermediate fragments. Some mafic fragments bear pale reaction rims, presumably caused by incipient reaction with a hot matrix. The heterolithic character and poor sorting of the fragments have the earmarks of pyroclastic flow deposits.

Bedding planes are steeply dipping, commonly overturned and strike east-northeast or northeast. The cleavage is commonly subparallel to lenticular bedding; features typical of bedding transposition. The boundaries between metavolcanic and metasedimentary belts are commonly faulted as indicated by the dextral strike separation of Proterozoic diabase dikes. Some fault zone rocks display strong silicification and Fe-carbonate alteration.

Narrow (≤1 km thick) linear zones of overturned, south-facing strata suggest the presence of regional stratigraphic top reversals within the southern BGB. Local younging directions as well as the angular discordance of stratigraphic horizons across a locally unfaulted contact seem to indicate a south-facing unconformity between the central metavolcanic and southern metasedimentary belts. The regional top reversals may be due to 1) stratigraphic inversion of panels of rock within an imbricate thrust wedge or 2) large-scale high-amplitude folding. The hypothetical hinge zones of the oppositely facing panels are unfaulted, an observation consistent with the latter interpretation. The pattern of overturned beds is consistent with either a train of upright eastward-trending folds which have elastica style or else with upright refolding of early recumbent folds.

GEOLOGY OF THE RED LAKE AND VARVECLAY-FAVOURABLE-WHITELOON AREAS, NORTHWEST ONTARIO

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The Red Lake and Varveclay-Favourable-Whiteloon areas straddle south and northeast margins of the Berens River Subprovince in Ontario. At these localities felsic plutonic rocks, which underlie most of the Berens River Subprovince, are in contact with the Red Lake and Favourable Lake greenstone belts, respectively. The new mapping shows irregular to lobate sodic and potassic batholiths that intrude the Red Lake greenstone belt. Although brittle fractures are common in most outcrops, few major ductile shear zones are identified in the felsic intrusions or at the north margin of the Red Lake greenstone belt. Several small metavolcanic and metasedimentary units are defined in the batholithic areas.

Geology of the southern Sachigo Subprovince, which lies northeast of the Berens, is dominated by large oval granite batholiths. The batholiths are separated by belts of sodic intrusive rocks and the Favourable Lake greenstone belt that extends from the Manitoba border more than 100 km southeast near Varveclay, Favourable and Whiteloon Lakes. The west end of the Favourable Lake greenstone belt is made up of highly deformed and metamorphosed mafic metavolcanic flows, intermediate fragmental rocks and clastic metasediments. Quartz arenite and marble units indicate that part of the belt originated as an early platform sequence. Two-mica granites, thought to be derived by anatexis of sediments, occur at edges of the greenstone belt. The northern Berens River Subprovince is underlain by an elongate granite batholith and irregular units of sodic intrusive rocks and gneisses. The dextral transcurrent Bear Head fault comprises a zone of mylonite that is developed locally along the subprovince boundary. At its southeast end near North Spirit Lake, the Bear Head fault curves east into the Sachigo Subprovince.

THE TECTONIC ASSEMBLAGE MAP OF ONTARIO

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The newly designed Tectonic Assemblage Map of Ontario illustrates the geology of the province from a new perspective. Its principal function is to display, through compilation and interpretation, the subdivision of lithostratigraphic successions into tectonic assemblages and the grouping of some of the intrusive complexes into plutonic suites. It also displays volcanic centres, structural features, and sample locations of U/Pb isotopic age determinations on zircons in magmatic units.

A **tectonic assemblage** is composed of stratified rock units that developed in a common depositional or tectonic setting during a discrete interval of time and is typically bounded by faults or unconformities. Assemblages can be subdivided into one or more groups or formations; the identification of tectonic assemblages in Precambrian rocks, particularly through the aid of field geology and geochronology, constitutes the first stage in the process of formal stratigraphic mapping. A **plutonic suite** comprises a set of plutons of common age, composition and probably common origin that are spatially associated and occur in a common tectonic environment. A new geochronometric subdivision for the Precambrian and a subdivision of Phanerozoic time into tectonic cycles, adopted for this map, will permit the map-user to visually identify patterns of ages for assemblages and plutonic suites across the province.

This map forms part of the folio of geological and geophysical maps of Ontario being produced at a scale of 1:1 000 000. It is accompanied by charts that summarize the main magmatic, sedimentary, structural and tectonic events recorded in the bedrock of Ontario. The charts complement the map by permitting regional correlation and interpretation of tectonic events. They also illustrate, for example, the episodicity of volcanic and plutonic activity more explicitly than is possible on the map.

Examples of parts of the Tectonic Assemblage Map illustrate the value of the map to researchers and mineral explorationists. We believe this type of map has many exploration applications; one can use this map to develop more detailed stratigraphic correlations and, in future, relate the distribution of different mineral deposit types to the environments of tectonic assemblages and their boundaries.

ARCHEAN PLUTONIC ROCKS IN THE SOUTHERN SUPERIOR PROVINCE: MAGMATISM DURING ARC-ACCRETION AND ITS METALLOGENETIC IMPLICATIONS

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The evolution of mantle- and crustal-derived igneous rocks in the Archean terranes of the southern Superior Province can largely be viewed as analogous to processes of Phanerozoic arc-developement and arc-accretion. Granitoid rocks in the Superior Province, ranging in age from 3.17 to 2.65 Ga, are subdivided into 6 major suites: gneissic tonalite; foliated tonalite; two-mica (S-type) granite; biotite granite-granodiorite; diorite-monzonite; and diorite-syenite. Each of these six suites is associated with particular stages of the accretionary process. Foliated tonalite and gneissic tonalite suite plutons older than 2.8 Ga represent cratonic slivers that predate the main arc-developement. Foliated tonalite suite rocks, that occur as composite plutons associated with volcanic rocks, formed during the main period of arc construction and predate tectonism. Syntectonic 2.7 Ga gneissic and foliated tonalite suite rocks were emplaced during collision events and with thrusting, contributed to crustal thickening.
Late- to posttectonic, mantle-derived diorite-monzonite and diorite-syenite suite plutons and associated shoshonitic to alkaline volcanic rocks are similar to those developed in the terminal stages of subduction in Phanerozoic regimes. These mantle-derived suites are coeval with late- to posttectonic granite-granodiorite and two-mica granite suite rocks that postdate arc-arc and arc-continent collision and are derived from melting of tectonically thickened crust.

Most of the plutonic suites have characteristic metallogenetic associations. Synvolcanic foliated tonalite suite plutons are locally associated with volcanogenic massive sulphide deposits (e.g. Beidelman Bay Pluton near Sturgeon Lake). Two mica granite plutons have a well-defined association with rare-element (Be, Li, Ta and rare-earth-element) pegmatites (e.g. Ghost Lake Batholith near Dryden). Diorite-monzonite and diorite-syenite suite plutons are commonly spatially associated with gold mineralization (e.g. Kirkland Lake area). In addition, diorite-monzonite suite rocks are temporaly associated with late- to posttectonic "Alaskan-type" mafic-ultramafic plutons that are host to Cu, Ni and platinum-group-elements mineralization (e.g. Lac des Iles near Thunder Bay).

MICROBIAL BIOFILMS: GLOBAL SIGNIFICANCE FOR THE GEOCHEMISTRY, IMMOBILIZATION, AND MINERALIZATION OF METALS IN NATURAL WATERS

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Field studies in many different aquatic environments have shown the presence of microbial biofilms to be ubiquitous on submerged substrates, varying from 10^3 to 10^7 bacteria/cm^2. Therefore, we suggest that the rock/water interface in reality consists of the rock/biofilm/water interface and that "biofilms" are an important integral part of the geochemistry of natural waters and the rock/water interface. Collected field data and laboratory simulations of aquatic systems have shown that these microbial biofilms are of global significance with regard to the geochemistry, immobilization, and mineralization of metals in solution. Metal uptake studies indicate that microbial biofilms adsorb up to 3 orders of magnitude more metal than uncolonized abiotic surfaces. Results also indicate that bacteria can adsorb more metal under neutral pH conditions than under acidic pH conditions. The adsorption of these metals subsequently leads to the precipitation of many different mineral phases on the surface of the cells or within their extracellular polymers. Microbial biofilms have been shown to precipitate a granular iron oxide (ferrihydrite) with trace amounts of silica under neutral pH conditions and acicular ferrihydrite crystallites containing traces of sulphur under acidic conditions in heavy metal contaminated waters. Evidence from transmission electron microscopy of biofilms and natural sediments suggests that many authigenic clay minerals may form in association with microbial biofilms. In addition, laboratory simulations using the unicellular cyanobacterium Synechococcus and filter-sterilized alkaline lake water revealed the precipitation of gypsum, calcite, and magnesite. Isotopic data shows that Synechococcus precipitated carbonate is enriched in ^{13}C due to the fractionation of ^{12}C by the cell during photosynthesis. In conclusion, the present field and experimental evidence highlights the importance of microbial biofilms for various mineralization processes at solid/liquid interfaces. Finally, given the universal abundance and distribution of biofilm forming prokaryotes over geologic time we suggest that they may be responsible for a large proportion of many sedimentary deposits since the Archean.

DRIFT PROSPECTING IN THE BEARDMORE-GERALDTON AREA

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A Canada-Ontario Mineral Development Agreement program of glacial geological research was initiated in the Beardmore- Geraldton area of northern Ontario in 1986. The program was carried out as a joint effort of the Geological Survey of Canada and the Ontario Geological Survey. The study was meant to test the usefulness of and provide guidelines for drift sampling as a mineral exploration method. Elsewhere, it has been shown that analysis of the geochemistry, mineralogy and lithology of surficial sediments can lead to the discovery of the mineralized bedrock which acted as the source of glacially dispersed debris.

Following collection of field data, the surficial geology of the study area was mapped using air photo coverage at a scale of 1: 15,840. Preliminary maps at a scale of 1:50,000 have been released. Surface till samples were collected from a depth of 0.7 to 1.0 m, in the upper C horizon or the B/C transition. The C horizon is considered oxidized material on the basis of its brownish colour and the lack of preserved sulphide minerals. Material such as carbonate has not been removed from this horizon by leaching. The C horizon was chosen for the determination of drift provenance because it is the least-altered material available from surface. Evaluation of the use of shallower soil horizons for geochemical exploration was considered beyond the scope of the project. Till obtained from deeper than three to seven metres in drill holes on well drained sites is olive grey, contains unaltered sulphides and is therefore unoxidized. Sampling and drill hole sites were located at roughly 1 km spacing along roads where appropriate material was available. A total of 900 till samples, most weighing about 15 kg, were collected, 505 from surface excavations in oxidized till and 395 from rotasonic drill core. A total of 87 samples of glaciofluvial sand and gravel were collected. These included 36 samples from pits in eskers, 24 from sand and gravel interbedded with till in drill holes, and 29 samples collected from a drill hole in thick sand near Beardmore. Samples were analyzed for geochemistry of three or more fractions, mineralogy of heavy mineral concentrates and gravel fraction lithology.

A major conclusion of the study is the recognition that near Beardmore, samples from the uppermost metre of thin, discontinuous till contain fine-grained visible gold and geochemical patterns indicative of nearby mineralization. This is an indication that soil sampling is likely to be an effective exploration tool in portions of this area where till is exposed at surface. In the Wildgoose Lake-Geraldton area, however, thick till is largely composed of Paleozoic carbonate and Proterozoic metasedimentary rocks derived from the Hudson Bay Lowland at least 150 km to the northeast. This exotic material dilutes and/or buries locally derived debris, so drilling is required in much of this area for more locally derived till to be obtained. This local till is more likely to reflect nearby mineralization than is the exotic till.

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NEW PATTERNS SEEN IN ONTARIO GEOLOGY: LESSONS FROM THE 1991 BEDROCK GEOLOGY MAP OF ONTARIO

P.C.Thurston and compilers of the Bedrock map.

New bedrock, tectonic, Quaternary, magnetic and gravity maps of Ontario are nearing completion. The bedrock map exhibits more lithological subdivisions than the 1971 edition. However, a clear distinction is maintained between related units by using groups of colours. The legend is geochronometric in the Precambrian and geochronologic in the Phanerozoic.

The Superior Province is divided into shear zone-bounded subprovinces characterized by similar rock types, structural history, mineral deposits and metamorphic grade and a limited range of U/Pb ages. In the Superior Province, supracrustal rocks within greenstone belts are of Meso- and Neoarchean age. To depict age/lithotype groupings effectively, supracrustal rock types are subdivided into: ultramafic to mafic, mafic to intermediate and intermediate to felsic metavolcanic units, metasedimentary rocks with subordinate mafic to ultramafic metavolcanic rocks, and metasediments. These are locally overlain by unconformable units of coarse clastic metasedimentary rocks with subordinate alkaline metavolcanic rocks (Timiskaming equivalents). These groupings define lithostratigraphic associations which aid in showing that greenstone belts are composite units formed of several associations of variable ages. A concentration of >2900 Ma greenstones occurs in Sachigo subprovince. A unit for migmatized supracrustal rocks permits display of the degree to which vestigial supracrustal units in katazonal regions such as parts of the Sachigo subprovince and the Wawa subprovince are continuous into major greenstone belts. Metasedimentary subprovinces are composed of metasedimentary rocks and their migmatized equivalents, muscovite-bearing granites and subordinate tonalitic units. Granitic rocks of the Superior Province are separated into suites listed in order of decreasing age: Gneissic Tonalite Suite, Foliated Tonalite Suite, Diorite-Monzonite-Granodiorite suite (DMG), Muscovite-bearing granite, and Massive Granodiorite to Granite. All are cut by Neoarchean Diorite-Nepheline Syenite Suite rocks. Muscovite-bearing units and the DMG suite show some tendency to concentrate along major shear zones.

Subdivision of the Proterozoic is comparable to the 1971 edition of the map with great improvement through geochronologic constraints on correlation of physically isolated units such as the Animikie and the Keweenawan. The major swarms of diabase dikes and alkaline intrusions of three ages are shown.

Units in the Grenville province are based upon the tectonic subdivision into the Central Gneissic Belt and the Central Metasedimentary Belt (CMB). Within these divisions, lithological subdivision is employed. These subdivisions portray a belt-like subdivision of the CMB into distinct sub-units. Likewise, the Gneissic Belt is subdivided into several sub-units.

The Phanerozoic has been subdivided lithostratigraphically; the legend identifies stratigraphic units of northern and southern Ontario. The subdivision of the Phanerozoic allows distinction of the two northern Ontario basins. Minor revisions to the Mesozoic include subdivisions within the Moose River Basin and the presence of a minor Cretaceous unit in far northwestern Ontario.

GOLD METALLOGENY ALONG THE DESTOR PORCUPINE DEFORMATION ZONE EAST OF MATHESON

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During the 1989-1990 field seasons, geological mapping was focused in Hislop, Gulbord, Michaud and Garrison townships, an area to the east of Matheson through which the Destor Porcupine deformation zone (DPDZ) directly passes. The purpose of the project was to determine the extent and nature of areas of high strain related to the DPDZ, and to use these characteristics together with metamorphic and alteration data to further constrain the location and timing of gold mineralization here.

Early workers in the area defined the position of the Destor Porcupine (DP) 'fault zone' or 'break' by a distinct change in facing directions, best evidenced by pillow orientations in basaltic sequences. This feature has been noted across other Archean deformation zones in Ontario and elsewhere. Close to the 'break', facing directions can become more erratic, and tight isoclinal folding is indicated in some instances. This is complicated by the 'melange' of lithologies commonly found in the DPDZ, generally consisting of altered ultramafic rocks, Porcupine and/or Timiskaming sedimentary rocks plus felsic intrusions, for which facing indicators may be rare or entirely absent. Furthermore, field work to date indicates that a much more extensive zone of deformation may exist about the DP 'Break', such that the traditionally perceived position of the main 'fault zone' may be but one component of the DPDZ. Zones of high strain that comprise the DPDZ can be broadly subdivided into two principal orientations, consisting of 070° striking and 110° striking segments. Deformation within the DPDZ is dominantly brittle, and few kinematic indicators are available. North to northeasterly striking cross faults commonly produce significant lithological and structural truncations (evident on aeromagnetic maps), and are often marked by Matachewan diabase dikes in the west half of the area. The intersection of these faults into the DPDZ often coincides with areas of significant gold mineralization.

Granitoid intrusions are of two main types: (1) calc-alkaline quartz bearing and (2) alkaline quartz poor. The calc-alkaline suite appears older, and are cut by syenitic phases. Many of the intrusions are tightly confined within a network of high strain zones comprising the DPDZ. Amphibolitic contact aureoles are variable width are present around some intrusions, while their absense is indicative of fault contacts with country rocks for others. Lamprophyre dikes are common in the region, but they appear to be more strongly concentrated in areas of gold mineralization. These dikes are often deformed and weakly mineralized and appear to post-date the syenite intrusions which may also host gold ore.

Gold mineralization is hosted by all lithologies represented in the area except diabase, and most often occurs at or near the contact of rheologically distinct units. Virtually all gold mineralization in the area is quartz±carbonate vein and fracture controlled, and their orientations generally mimic that of the DPDZ. Specular hematite alteration is widespread, especially in association with syenite, while ankeritic carbonate, sericite, green mica and anhydrite alteration are typically common in association with gold. The Buffonta deposit, which occurs within an intrusion contact aureole, departs somewhat from these characteristics. Fracture controlled mineralization post-dates a metamorphic calc-silicate alteration, but the significance of this timing difference remains unresolved.

To date, over 40 occurrences of gold mineralization are documented in this area, but only the recently closed Ross Mine has been a prolific producer (>1 million ounces). The overall distribution of gold deposits and occurences in the area suggests a strong spatial association with the DPDZ. However, no deposits occur directly in the main 'break'. Because of the overall low bedrock exposure, the excellent accessibility, and the positioning of the area between the Timmins gold camp to the west and the Harker-Holloway gold camp to the east, this area is considered to have high potential for undiscovered economic gold mineralization.

ECONOMIC GEOLOGY AND GEOCHEMISTRY OF GRENVILLE CARBONATE ROCKS

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Metamorphosed carbonate and calc-silicate sedimentary rocks underlie much of the Central Metasedimentary Belt of the Grenville Province in southeastern Ontario. These economically-important marbles are mined to produce dimension stone, decorative aggregate, crushed and ground rock for mineral filler and other applications, talc, and magnesium metal. They also have potential for producing graphite, wollastonite, and zinc.

A set of four marble-related data files intended for analysis on personal computers, have been prepared for release on floppy disk as an Open File Report. Two data files contain whole rock and trace element geochemical analyses and sample locations for 1912 samples which were collected across the marble belts, and another file contains sample descriptions, including mineralogy ("impurities"). These geochemical and sample description data were previously published in paper form by Grant et al (1989). The fourth data file, prepared by H.D. Meyn, MNDM's Regional Specialist and his staff, contains quite detailed information about 636 mineral occurrences which occur within Grenville marbles.

The data can be used with a personal computer to plot the spatial relationships between, for example, known occurrences of graphite, and graphite-bearing samples in the rock sample data set. The locations of rock samples with a specific composition can be plotted on a map together with, for example, known occurrences of zinc and the locations of rock samples which are anomalous in zinc. Data subsets such as data from individual marble belts can be examined. Within some areas the sample distribution is dense enough to allow a reasonable attempt at contouring. An example is contouring of silica values to identify areas of low-silica marble which might be valuable for producing mineral fillers.

Computer analysis of the marble-related data is an ongoing project in MNDM's Southeastern District, and potentially economic marble areas which are suggested by this work will be examined in the field during 1991. The data have been prepared on floppy disk for Open File release, so that prospectors and the exploration industry may use them now.

REFERENCE

Grant, W.T., Papertzian, V.C., and Kingston, P.W. 1989. Geochemistry of Grenville marble in southeastern Ontario; Ontario Geological Survey, Mineral Deposits Circular 28, 266 p.

ONTARIO AGGREG\TE RESOURCES INVENTORY PROJECT.

Staff of the Aggregate Assessment Office, Engineering and Terrain Geology Section, Ontario Geological Survey.

The ongoing activities of Ontario's Aggregate Assessment Office are presented. The Aggregate Assessment Office of the Ontario Geological Survey has published 130 Aggregate Resources Inventory Papers and reports over the past decade. These published reports cover 70% of southern Ontario and selected areas in northern Ontario. The reports include a detailed assessment of sand, gravel and bedrock resources. The quality and quantity of the aggregate resources are discussed and deposits are ranked according to their potential for extractive development. Specialized investigations have also been conducted in several areas to help meet demands associated with mine and access road developments in remote areas, to solve specific aggregate quality problems and to delineate buried aggregate resources.

Detailed field investigations are an integral part of the aggregate resources inventory process. Field activities include the examination of all available exposures of granular materials as well as assessing the nature of subsurface aggregates by conducting surveys using hand augering, test hole drilling or excavation, and geophysical techniques. Field work undertaken in the summer of 1990 included the assessment of aggregate resources within eight geographic townships in Victoria, Peterborough and Haliburton Counties. Photographs on display depict the characteristics of selected aggregate deposits in these townships. Field work was also conducted in the Moosonee area and the preliminary results of this aggregate resources inventory are presented in a separate display. (*see* abstract titled Aggregate Resources Inventory of the Moosonee Area).

REGIONAL SYNOPSIS OF THE LAKE OF THE WOODS GREENSTONE BELT

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The poster summarizes results of a 2-year synoptic investigation of the Lake of the Woods greenstone belt (LWGB).

The LWGB is a structurally and lithologically complex collage of metavolcanic and subordinate metasedimentary sequences intruded by granitoid rocks within the western Wabigoon Subprovince. It is bordered to the north by the Winnipeg River Subprovince (WRS). Supracrustal stratigraphy is subdivided into 3 supergroups. The oldest supracrustal rocks are thick tholeiitic mafic volcanics of the Lower Keewatin Supergroup (LKS). Rocks of the Upper Keewatin Supergroup (UKS) conformably overlie those of the LKS. The UKS is subdivided into complexly intercalated stratigraphic subunits with 2 main lithological groupings: 1) groups comprised predominantly of calc-alkalic volcanics with locally extensive mafic volcanic formations of tholeiitic to komatiitic affinity, and minor clastic and chemical sediments; and 2) laterally extensive turbiditic sedimentary rocks. The youngest supracrustals are those of the 2 sedimentary groups of the Electrum Lake Supergroup (ELS). The Crowduck Lake Group unconformably overlies the UKS and is comprised of conglomerates interbedded with arenaceous sediments. The White Partridge Bay Group conformably overlies the UKS and consists of fine-grained arenaceous to argillaceous sediments with conglomerates restricted to the upper reaches. Two major deformation events have affected the LWGB. N-S directed D1 compression resulted in subhorizontal F1 folds and dip-slip movement on early narrow thrust faults. NW-SE directed D2 transpression resulted in subvertical F2 folds and transcurrent strike-slip movement on broad deformation zones.

Volcanism occurred during a period of about 21 million years from at least 2732 Ma for the LKS and from about 2728-2711 Ma for the UKS. Pre-tectonic plutonism was coeval with UKS magnetism while late- to post-tectonic plutonism postdates it to a minimum age of about 2660 Ma. D1 and D2 deformation are closely bracketed between 2711-2709 Ma. Gold mineralization is restricted to vein systems hosted by D2 deformation zones. Many are in close proximity to syn- to late-tectonic felsic intrusions and may have formed in direct response to the emplacement of the intrusions coeval with the transpressive deformation event.

An Archean plate tectonic model for the LWGB implies creation of the LKS tholeiites as oceanic crust and/or the basal portion of an island arc succession. Subduction and partial melting of oceanic crust in a north-dipping subduction zone beneath the WRS resulted in calc-alkalic magnetism expressed as UKS volcanism with coeval plutonism. Emergent edifices late in the evolution of the island arc contributed to laterally extensive resedimented facies distal turbidites in the upper part of the UKS in the south and resedimented facies grading to alluvial-fluvial conglomerates in the more restricted basins of the ELS in the north. D1 compression occurred as the fore-arc was obducted onto the WRS with thrust faulting and subhorizontal F1 folding. Island arc-continental collision would result in a transpressive D2 event with resulting verticalization of D1 structures, subvertical F2 folds and transcurrent movement on the D2 deformation zones. Finally, detachment of the subducting oceanic crust beneath the WRS would result in post-tectonic plutonism within both the LWGB and the WRS.

QUATERNARY GEOLOGY OF THE HUNTSVILLE-BRACEBRIDGE AREA.

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Detailed Quaternary geology mapping of the Highway 11 corridor between Huntsville and Bracebridge was undertaken as part of a two year mapping program. Future mapping will extend to the south and west into the Gravenhurst, Penatanguishene and Christian Island areas. In addition to providing a Quaternary geology database for the study area, the project is identifying exceptional geological features to be considered for protection under provincially and municipally-run heritage programs.

The Quaternary deposits in the study area are believed to be late Wisconsinan and Holocene in age. The direction of the last glacial advance was southward across the study area. Much of the region is characterized by a rock-dominated terrain where drift only locally attains substantial thicknesses. The thickest drift occurs along major north-trending drainage routes.

The area was deglaciated approximately 11 000 years B.P. Glacial Lake Algonquin fronted the retreating margin of the ice sheet over most of the western half of the study area. Deposits of subaqueous outwash and glaciolacustrine sediments occupy low-lying areas within this region. High ground within the eastern half of the study area remained unaffected by glacial lake processes. This highland area is characterized by thin, discontinuous deposits of sandy till and glaciofluvial deposits.

QUATERNARY STRATIGRAPHY OF THE BARRIE AREA.

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The stratigraphy of the Barrie area is currently under investigation as part of a program of Quaternary geological mapping in the eastern halves of the Barrie (NTS 31D/5) and Elmvale (NTS 31D/12) map areas.

The thickness of the Quaternary deposits overlying the bedrock surface in these map areas can exceed 140 m. Natural exposures of deposits occurring below the surface sediments are rare. To obtain information on the distribution and types of Quaternary sediments occurring at depth, eight boreholes were drilled in the vicinity of the Barrie, Ontario.

The drilling program was designed to obtain better information on the entire sequence of Quaternary sediments and to provide a framework for the interpretation of downhole geophysical logs. Six of the boreholes were later geophysically logged using natural gamma, gamma-gamma (density), and neutron tools. Dr. John Greenhouse and George Scheider, of the Department of Earth Sciences of the University of Waterloo, provided the logging equipment and conducted the geophysical surveys.

The subsurface geology in the Barrie area is very complex, consisting of multiple layers of diamicton (flow, deformation, and lodgement till) interbedded with glaciolacustrine sand, silt and clay deposits and glaciofluvial sand and gravel deposits. Several major glacial events are indicated in the sequence of sediments encountered. Minor ice marginal fluctuations of the same glacier are also recorded. The ice margin appears to have been in contact with and supporting proglacial lakes when in the Barrie and Elmvale map-areas. Fine-grained till layers, the product of the incorporation or deformation of fine-grained glaciolacustrine sediments, occur in several of the boreholes.

The results of the drilling indicate that the stratigraphy of the uplands is quite different from the stratigraphy of the sediments below the valley floors. The uplands are composed of several layers of till interbedded with glaciolacustrine sediments. Thick glaciofluvial deposits of very coarse sand with minor gravel occur beneath postglacial glaciolacustrine sediments below the valleys. Detail logs of the boreholes are to be released in an Open File Report.

EXPLORATION AND DEVELOPMENT ACTIVITIES IN THE COBALT AREA 1990

Baša, E.M., Mines and Minerals Division, Resident Geologist's Office

Production activity in the Cobalt area has dropped significantly from last year with the closure of the area's last silver mine and of the Sherman iron ore mine in Temagami.

Development activity has remained low in the area with only the former Tyranite gold mine under re-evaluation in Knight and Tyrrell townships.

Staking activity was elevated this spring, due to the re-opening of lands peripheral to the Bear Island Indian Land Caution. Depressed gold prices and lack of exploration funding hindered further development of these properties. However, many small companies and prospectors carried out substantial grass roots exploration in both the Shining Tree and the Hill Lake areas near Elk Lake.

Completed COMDA research includes geological studies of Banting and Best townships, a mine workings compilation study, and compilation of Geological Data Inventory Folios.

AN INTEGRATED GEOSCIENCE INFORMATION SYSTEM, WAWA DISTRICT

Beach, P.D., Henri, R.J. and D.J.J. Tortosa
Wawa Resident Geologist's Office, M.N.D.M.

A computer compilation and integration of geological, geophysical, geographical, and topological data for the Wawa District has been undertaken to provide a user-friendly method of handling digital geoscience information. The main component of the system is QUIKmap, an archival G.I.S. (Geographic Information System) software used on IBM-compatible computers. QUIKmap is a raster and vector based graphics-database system which is simple, fast, memory efficient, and able to accomodate all common map projections.

Basemap and database preparations have involved the acquisition, compilation, digitization, conversion, geographic referencing and accuracy checking of the data. Sources of the digital information include: The Wawa Resident Geologist's Office, the Ontario Geological Survey, Energy, Mines and Resources Canada, the Ontario Centre for Remote Sensing, the Ministry of Natural Resources, and the Sault Ste. Marie Drill Core Library.

Partial or full coverage of database-linked digital information (point or polygon) includes: whole rock and lake sediment geochemistry, mineral deposits, diamond drill holes, the assessment file index for Point Isacor, land-use information, mineral potential, exploration activity, and claim data. Digital basemap coverage includes: topographic contours, water boundaries, township boundaries and transportation routes as individual layers at 1:50 000 and 1:250 000 scales. Geoscience map data includes: regional and detailed geology, interpreted lineament data from radar and Landsat images, contoured aeromagnetic data, and electromagnetic data.

The integration of the digital information on a G.I.S. provides a user-friendly tool that allows for rapid access to a wide variety of geoscience knowledge in the Wawa District, and gives the geologist with limited computer skills the ability to do a variety of geological and interpretive functions, e.g. overlay geophysical and geological data.

GEOGRAPHIC INFORMATION MANAGEMENT FOR MINERAL RESOURCES PLANNING, WAWA DISTRICT

Beach, P.D., Henri, R.J. and D.J.J. Tortosa
Wawa Resident Geologist's Office, M.N.D.M.

Geographic information management for mineral resources and land-use planning is becoming increasingly important in the Wawa Resident Geologist's District. An archival geographic information system (G.I.S.) is used to rapidly compile, maintain, update, and retrieve information, and to produce maps and reports. QUIKmap, a simple to use G.I.S. software package, forms the main component of the graphics-database system, and links the different database elements with map layers.

Information compiled from MNDM and MNR sources include: lodges, commercial outpost camps, cottage lakes, canoe routes, environmentally sensitive areas, parks, Indian reservations, potential hydro-electric power generating sites, sand and gravel quarries, and mining developments. Mineral potential maps for a selected area were also produced for internal use, with QUIKmap.

The ability to manage geographic information using these kinds of software tools, aids the Wawa Resident Geologist's office by providing rapid, up-to-date information on potential resource conflicts between the mining industry and other land users.

GEOLOGY OF THE CASUMMIT LAKE AREA

G.P. Beakhouse, Precambrian Geology Section, Ontario Geological Survey

The Casummit Lake area is located at the north end of the Birch-Uchi greenstone belt. All of the bedrock in the area is inferred to be of Archean age.

The metamorphosed supracrustal rocks of the map-area can be subdivided into a northern mafic association (NMA) and a southern heterolithic association (SHA). This subdivision may have significance for mineral exploration in as much as many of the known gold occurrences lie within 500 metres of the NMA-SHA transition.

The NMA consists almost entirely (>95%) of massive, pillowed and auto-brecciated mafic flows. Minor chert-magnetite ironstone interflow units that are rarely more than 1 meter thick are common. Minor intermediate fragmental metavolcanic rocks and clastic metasedimentary rocks are interbedded with the metabasalt near the transition between the two associations.

The SHA consists predominantly of intermediate tuff, lapilli-tuff and tuff-breccia but also contains significant amounts of mafic flows (~10-15%) and felsic pyroclastic deposits, flows and massive porphyries (~5%) as well as clastic metasedimentary rocks (~5%) and minor chert and magnetite ironstone.

The supracrustal rocks have been intruded by; (1) large external granitoid complexes which bound the greenstone belt, the emplacement of which is responsible for much of the deformation, (2) the Mink Lake granodiorite stock which hosts a disseminated molybdenite deposit, and (3) minor gabbroic to dioritic mafic plutons.

A moderate to strong tectonic fabric (=D_2 in the previously mapped Birch Lake area to the south) is parallel to bedding throughout most of the map-area. D_1 fabrics have not been observed in the present area. Bedding and D_2 structures are folded about axes plunging steeply north with the attendant development of an axial planar fabric and conjugate shears (D_3). The result is a complex geometrical arrangement of structures which cannot be consistently differentiated.

Gold mineralization is spatially associated with lithologic contacts, especially the NMA-SHA transition. This is interpreted to be due to the presence of structures (intense fabric, shears) which developed preferentially near lithological contacts and served to focus fluid flow responsible for alteration and gold mineralization. The geometry of veins is controlled by both D_2 and D_3 structures, and therefore almost any orientation of veins is to be expected within these favorable zones.

THE MacGREGOR ROAD BRECCIA

Bennett, G., Resident Geologist, Mines and Minerals Division

An unusually large breccia is centered around Latitude 46 degrees 20' 20" N and Longitude 83 degrees 46'05" W.; about 40 km. southeast of Sault Ste. Marie, Ontario. The breccia zone is about 4 km. long and up to 200m wide. It is emplaced along the south side of a wedge-shaped fault-block of arkose of the Lorrain Fm. of the Huronian Supergroup which has been down-faulted into conglomerates, sandstones and mudstones of the Gowganda Formation. Where observed, the walls of the breccia are approximately vertical. Extensive albitization and silicification of wall rocks, especially the mudstones, is common near the western end of the breccia zone. Pyrite and specular hematite are locally prominant in the breccia matrix. Several radioactive areas a few meters across were detected. The breccias within the zone range from matrix-supported polymictic types, to only slightly rotated, monomict blocks several meters to tens of meters across. The breccia clasts are angular to rounded with no evidence of deformation of clasts or matrix. The matrix is composed of comminuited rock fragments. The only breccia clast lithologies observed are those found in the Gowganda Formation, Lorrain Formation and, rarely, Nipissing Diabase. The clast lithologies observed suggest that clast movement is mainly downward, with no evidence of upward gas streaming. Cross-cutting relationships indicate that breccia development was contemporaneous with Nipissing Diabase intrusion. It is suggested that the emplacement of large bodies of Nipissing magmas resulted in the faulting and down-dropping of a block of Huronian rocks. Dilatent zones formed along one or more sides of the block resulted in the formation of the breccia bodies. Although the MacGregor Road breccia shares some of the features of the copper-bearing breccias of the north shore of Lake Huron area, and some features of the gold-bearing beccias of the area northeast of Sudbury, preliminary sampling has yet to reveal significant values in gold or copper.

LITHOGEOCHEMICAL STUDY OF THE ARCHEAN VOLCANIC ROCKS OF THE WHISKEY LAKE GREENSTONE BELT, ALGOMA DISTRICT, ONTARIO.

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R.E.S. Whitehead, Associate Professor, Department of Geology, Laurentian University, Sudbury, Ontario

To assist in assessing the economic mineral potential of the Whiskey Lake greenstone belt, a three-year lithogeochemical study, funded by the Ministry of Northern Development and Mines, has been initiated. The project is being carried out by staff from the Department of Geology, Laurentian University in collaboration with the Ontario Geological Survey. The Whiskey Lake Belt is situated about 6 km southeast of the town of Elliot Lake and is bounded by rocks of the Proterozoic Huronian Supergroup, preserved in the Quirke syncline to the north, and Archean granitoid rocks to the south.

Most of the exploration activity in this region has focused on uranium in rocks of the Huronian Supergroup to the north of the greenstone belt. The Whiskey Lake greenstone belt has not been explored extensively for precious and base metal mineralization. Few signs of recent or past exploration activity were encountered during the sampling program.

About 550 samples were collected during the first field season from parts of Proctor, Deagle, Gaiashk, Joubin and Gerow townships. Samples were collected along pace and compass traverses controlled by air photos and laid out to ensure a relatively consistent, unbiased, 400 m sample spacing. All samples have been analysed for Au, Na, Ca, Sc, Cr, Fe, Co, Ni, Zn, As, Se, Br, Rb, Sr, Mo, Ag, Sb, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Hf, Ta, W, Ir, Th, and U, by neutron activation. CO_2 determinations have been completed on selected samples. Major element and Cu, Pb, Zr and Y analyses are presently being done by X-ray fluorescence. The geochemical data will be entered into the OGS FIELDLOG program to generate a digital data base and to facilitate comparison between areas of anomalous geochemistry and specific geological features. Areas that display anomalous geochemistry, or which are characterized by geology known elsewhere to be favorably disposed to the presence of massive base metal sulphide or gold mineralization, will be investigated in greater detail.

The results of this geochemical study will be presented on anomaly maps to: 1) help delineate areas which possess geochemical and geological features suggestive of economic mineralization; and 2) provide geochemical data to assist in the interpretation of the regional geology.

MULTI-SPECIES (~30) FLUID INCLUSION CATION / ANION / VOLATILE ANALYSIS (ION / GAS CHROMATOGRAPHY; ICP-AES) APPLIED TO THE HOLLINGER-McINTYRE AND KERR ADDISON ARCHEAN Au-QUARTZ VEIN SYSTEMS.

CHANNER, D.M.DeR., BRAY, C.J. and SPOONER, E.T.C., Department of Geology, University of Toronto, 22 Russell St, Toronto, M5S 3B1.

Separate techniques have been developed to analyse fluid inclusion ions and volatiles by ion and gas chromatography (IC and GC) respectively. In the IC technique 20 species have been quantified in standard solutions; these species are (minimum detection limits in ppb in injected sample follow each species; anions and cations listed in order of increasing retention time): F^- (14), CH_3COO^- (12), $HCOO^-$ (4), Cl^- (6), NO_2^{2-} (9), Br^- (19), NO_3^-, (16), HPO_4^{2-} (28), SO_4^{2-} (26), $C_2O_4^{2-}$ (oxalate; 250), I^- (20) Li^+(0.5), Na^+ (0.7), NH_4^+ (0.6), K^+ (1.6), Rb^+ (3.5), Cs^+ (5.9), Mg^{2+} (5), Ca^{2+} (15), and Sr^{2+} (100). Of these species 10 (Cl^-, Br^-, SO_4^{2-}, Li^+, Na^+, K^+, Rb^+, Cs^+, Mg^{2+}, and Ca^{2+}) have been detected by crush / leach analysis of 0.5-2g electrolytically cleaned quartz reference samples from the Tanco granitic pegmatite. Precisions for concentrations of species in standards and reproducibilities of species peak areas are ±5%. System blanks, determined using heat treated Brazilian quartz, were 0.5% or less of species peak areas in samples except for Na^+ (2.5%), K^+ (7%), and Ca^{2+} (11%). Additional species were determined by ICP - AES analysis of leachates prepared using an acidified leachate solution. In the GC technique 18 fluid inclusion volatile peaks have been detected and identified from 1-2g samples (quartz) using heated (~105°C) on-line crushing, helium carrier gas, a single porous polymer column, two temperature programme conditions for separate sample aliquots, micro-thermal conductivity (TCD) and photoionization detectors (PID; 11.7 eV lamp) and off-line digital peak processing. In order of retention time these volatile peaks are: N_2, Ar, CO, CH_4, $C0_2$, C_2H_4, C_2H_6, C_2H_2, COS, C_3H_6, C_3H_8, C_3H_4 (propyne), H_20 (22.7 mins at 80°C), SO_2, ± iso-C_4H_{10} ± C_4H_8 (1-butene) ± CH_3SH, C_4H_8 (iso-butylene), (?) C_4H_6 (1,3 butadiene), and ± n-C_4H_{10} ± C_4H_8 (trans-2-butene). Blanks determined by crushing heat treated Brazilian quartz (800-900°C/4 hrs) are zero for 80°C temperature programme conditions, except for a large, unidentified peak at ~64 mins, but contain H_2O, CO_2 and some low molecular weight hydrocarbons at -70°C temperature conditions due to cryogenic accumulation from the carrier gas and subsequent elution. TCD detection limits are ~30 ppm molar in inclusions; PID detection limits are ~1 ppm molar in inclusions and lower for unsaturated hydrocarbons (e.g. ~0.2 ppm for C_2H_4; ~1ppb for C_2H_2; ~0.3 ppb for C_3H_6). Precisions are ~±1-2%, except for H_2O (~±13%). Maximum concentrations of species in fluid inclusions have been calculated from the IC leachate data using values of moles H_2O / g quartz from GC analyses of sample splits. Recently the two techniques have been combined so that a sample which has been crushed for GC analysis can then be leached for IC analysis. Detailed fluid inclusion petrography and microthermometry is a pre-requisite for these bulk analytical techniques and is in progress on the Hollinger - McIntyre and Kerr Addison samples. The aim of the research is to define the chemical composition of primary and secondary fluids in the vertical and lateral dimensions of the deposits in order to address questions of fluid sources, Au solution transport parameters, and positioning of ore zones.

RECENT MINING AND EXPLORATION DEVELOPMENTS IN THE SUDBURY AREA - 1990

Cosec, Michael, Sudbury Resident Geologist's District

Mining and exploration activities in the Sudbury area remained relatively healthy in 1990, as reflected by the sound price of nickel throughout the year.

Inco Limited operated nine underground mines, two open-pit mines, three mills, one smelter, two refineries, and one strip rolling mill. Annual nickel production was thought to be approximately 210 million pounds. Expansion of the Clarabelle mill continued, as did development at the McCreedy East, Lower Coleman, and Craig mines.

Falconbridge Limited had production from five underground and one open-pit mine yielding approximately 70 million pounds of nickel. Development continued at the Strathcona mine, but operations ceased at the East mine. Exploration and shaft-sinking at the T. L. Exploration shaft reached 1450 metres.

Orofino Resources Limited completed milling stockpiled gold ore from the Scadding mine.

Several varieties of building stone, as well as silica and dolomite were also produced.

Inco Limited and Falconbridge Limited conducted surface exploration on their patented claims in the Sudbury area, B.P. Canada Incorporated commenced extensive exploration on a gabbro-anorthosite intrusion in the Agnew Lake area, and junior mining companies were active in the Benny greenstone belt and east of Wanapitei Lake. Falconbridge Limited staked an extensive group of claims covering the southwest portion of the Temagami magnetic anomaly.

LITHOPROBE seismic reflection and high resolution geophysical surveys were completed across the Sudbury structure. A mineral occurrence study and building stone inventory were completed through COMDA funding. D. Peck of Laurentian University commenced a post-doctoral investigation of the mineral potential of rocks in the East Bull Lake area.

Determination of ngg^{-1} Gold in Geological Materials by Lead Fire Assay - GF-AAS.

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Following sample preparation, the precious metals in geological materials are pre-concentrated by the classical lead fire assay technique. Gold is then determined at the > 2 ngg^{-1} level by GF-AAS. The determination limit for this method is controlled by the concentration of gold in the flux.

Experience has shown that care must be taken to monitor the quality of chemical reagents and contamination of equipment used during all steps of the method, insuring that a high level of analytical precision and quality control (QC) is maintained.

MINERAL OCCURRENCE INVESTIGATIONS IN ESQUEGA TOWNSHIP, WAWA DISTRICT

Delisle, P.C., Wawa Resident Geologist's Office, MNDM

Sixteen mineral occurrences were mapped during the 1990 field season in Esquega Twp. About 50 percent were well stripped providing good exposure of lithology, structure and mineralization. Mineralized zones are controlled mainly by the complex structural settings and, to a lesser extent, by the geological contacts between adjacent rock types. Mineral occurrences can be subdivided into three groups based on mineralogical, structural and, in some cases, lithological characteristics.

The first group consists of refolded gold-bearing quartz veins in east-northeast trending shear zones, e.g. the Murray Algoma. Alteration products are biotite, ankerite and chlorite and associated sulphide assemblage consisting of chalcopyrite, pyrrhotite and pyrite.

The second group consists of gold-bearing sulphide fracture-fillings oriented in a north-northeast direction, e.g. the Lakemount #1 Vein. They consist of discrete, anastomosing quartz-carbonate breccia zones containing chalcopyrite, galena, sphalerite, pyrrhotite, bornite, pyrite and native copper. The alteration mineralogy is chlorite, sericite and minor biotite, epidote and calcite.

The third group consists of copper and nickel mineralization with minor PGE associated with a magmatic ultramafic intrusion at Elbow Lake. In 1969, Amax Exploration Inc. delineated 2 500 000 tons of ore containing 0.55% nickel and 0.36% copper.

A detailed open file report is in preparation which will describe each mineral occurrence in terms of structure, lithology, mineralogy, and alteration. It will also include assays, development history, and detailed geological maps. This project is supported by the Northern Development Fund (Wawa Economic Development Initiatives).

MODAL ANALYSIS OF GRANITES USING A QUANTITATIVE POWDER X-RAY DIFFRACTION METHOD.

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A long term goal of the Geoscience Laboratories Section is to provide a modal analysis for each rock submitted for chemical analysis. Quantitative powder XRD would appear to be the most promising method to achieve this goal. Use of an automatic divergence slit, a sensitive silicon detector, and a sample spinner greatly increase the precision of the method. Precision is also improved by ensuring that sample particle size is in the 1 to 10 um range. Initial work has been carried out on a suite of granitoid rocks from the English River Sub-Province. Results were obtained using three variants of the internal standard method. They show that the XRD technique can provide precise and accurate mineralogical data in minutes and is a viable alternative to optical methods for modal analysis of granites.

REGIONAL COMPARISON OF METASEDIMENTARY / METAVOLCANIC SEQUENCES IN THE MICHIPICOTEN GREENSTONE BELT, WAWA, ONTARIO

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Three noncontiguous belts of metasedimentary and/or metavolcanic rocks exist within the Michipicoten Greenstone Belt.

A northern belt trends easterly, effectively marking the boundary with the external granitoids. In the west, at Kabenung Lake, a thick near-vertical succession of pyroclastic and epiclastic rocks, represented by dust- to ash-grade quartz and/or feldspar phyric tuffs, fine-grained lapillistone, volcano-lithic arenites, and polymictic orthoconglomerates displays a consistent southwesterly facing direction. Of two compositionally different conglomerates, the most abundant mainly contains intermediate to felsic metavolcanics clasts; the other contains white metachert clasts with relatively minor mafic metavolcanic and oxide iron formation clasts. Turbidites are noticeably absent. Small exposures in one area of Dunphy Township suggest that the eastern end of the northern belt contains interstratified oligomictic conglomerate and quartz-rich arenite with a few felsic pyroclastic units. Quartzofeldspathic clasts constitute 20-30% of the conglomerate. Arenites are laminated to very thinly bedded, medium- to coarse-grained, and contain sparse clay laminae and quartzofeldspathic clasts. Primary sedimentary structures are absent.

A shorter NW-trending belt terminates north of Radford Lake. AE turbidites at the southern end of nearby Kapimchigama Lake give way northward to previously unreported quartz-rich arenites with minor fine-grained sediment. Stratification sequences are compatible with that of a siliciclastic shelf.

The northeastern half of a NE-trending belt containing the Wawa defoliated area received the most investigation. This area is characterized by a thick succession of interstratified pyroclastic and epiclastic sediment west of the Algoma Central Railway track, and pyroclastic, epiclastic and non-volcanogenic clastics to the east. The westerly pyroclastics include polymictic orthoconglomerate, fine- to coarse-grained tuff, and fine-grained lapillistone. AE turbidites are intimately interstratified with the pyroclastics. To the east, reworked volcanogenic conglomerates may represent debris flow deposition. Prominent AE turbidites occur locally with tuff units.

HIGH-RESOLUTION MAGNETIC-SUSCEPTIBILITY PROBE FOR MINERAL-EXPLORATION BOREHOLES: A PROGRESS REPORT

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Atherton, D.L., Physics Department, Queen's University

A borehole logging probe has been developed to detect small-scale magnetic features by recording variations in the probe's response as a function of its axial position. The objective is to determine the geologic and mineral-exploration significance of variations in susceptibility on a scale of millimeters to centimeters. The magnetic equivalent of a three-point measurement can be used to determine orientation of planar magnetic contrasts intersected by the borehole, a capability which is of interest in detecting the magnetic signatures of structural indicators.

The probe measures magnetic field anomalies (residual field detected by miniature Hall-effect sensors) corresponding to the ease with which the wall rock is magnetized in the presence of an applied magnetic field supplied by two powerful permanent magnets. In general, rocks are only slightly magnetic (paramagnetic) so the residual tends to be quite small in comparison to the applied field. The design phase was carried out with the Infolytica finite-element modelling program. It involved adjustment of size, shape, position and composition of the probe's internal components to maximize the ratio of residual field to applied field. Miniature Hall-effect sensors are used to detect the residual field.

Laboratory tests have been carried out with computerized data acquisition and a linear scanning apparatus to simulate the effects of simple situations under controlled conditions. This arrangement is also suitable for systematic scanning of drill core. The drillhole probe for field use is the same unit housed in a waterproof case, with the addition of inclinometers for orientation (non-vertical holes only). Examples are shown to illustrate the nature of high-resolution magnetic susceptibility variations and their potential utility in characterizing geologic environments.

GEOLOGY OF THE GRIMSTHORPE AREA, GRENVILLE PROVINCE (Project 90-19)

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The Grimsthorpe area is underlain by rocks of Middle to Late Proterozoic age which form part of the Elzevir Terrane of the Central Metasedimentary Belt of the Grenville Province. Metamorphic grade in the area is upper greenschist, although middle amphibolite rocks occur adjacent to the Weslemkoon and Canniff tonalites. Deformation in the map area is generally low, and is concentrated along several shear zones and in contact strain aureoles adjacent to tonalite plutons. Little mineral exploration has been conducted in the area.

The Grimsthorpe area is separated into two blocks by the NNE-trending Partridge Creek shear zone, which coincides with the western margin of the Killer Creek Gabbro Suite. The western block consists of a package of mafic volcaniclastic and minor mafic flow rocks and minor siliceous clastic and pyritiferous metasediments intruded by several ages of gabbro and mafic to intermediate dikes, as well as gabbroic and dioritic rocks of the Lingham Lake Suite and the Weslemkoon and Canniff tonalites. A series of older proto-mylonitic gabbros are found along the margin of the Canniff Tonalite. Cobbles of these gabbros occur in conglomerates within the volcaniclastic sequence and the gabbros may have served as basement to part of the supracrustal succession. Talc occurrences in the Grimsthorpe area, and to the south, are hosted within these older gabbros.

The eastern block consists mainly of gabbroic and ultramafic rocks of the Killer Creek Gabbro Suite which have been intruded by the Elzevir Tonalite. The younger Skootamatta Syenite intrudes both units.

The N-trending Mooroton shear zone lies just east of the map area and separates rocks of the eastern block from supra-crustal rocks, including the Flinton Group, of the Marble Lake area (*OGS Report 238*) to the east. Rocks of the Flinton Group do not occur west of the Mooroton shear zone, and a belt of gold occurrences lies along the eastern edge of the shear zone. The Mooroton shear zone appears to be a major, possibly mineralized, structure that divides the Elzevir Terrane into two parts.

Mineral potential in the area consists of oxide-bearing zones within the Killer Creek Gabbro Suite (ilmenite, chromite, magnetite), base metal deposits associated with an alteration zone in the central part of the area, gold related to the shear zones, and ultramafic-hosted talc deposits.

MINERAL RESOURCES, SOUTHWESTERN ONTARIO: CURRENT UTILIZATION - FUTURE POTENTIAL

Feenstra, B.H., Kelly, R. Southwestern District, Mines & Minerals Division

The bulk of Ontario's nonmetallic mineral and structural material wealth is derived from the industrial mineral resources of southwestern Ontario. Gypsum and salt production within Ontario is derived solely from the southwest as is much of the clay and shale production, most of the crushed stone, calcined lime, cement and "limestone" building stone production.

Salt is produced from room-and-pillar and solution mining operations. Uses include: de-icing products, chemical chlor-alkali manufacture, water softening, agricultural and food applications. Future opportunities exist in the chemical industry. An example is the use of salt to produce sodium cyanide, a primary chemical reagent in the extraction of gold and silver.

Gypsum is extracted by underground room-and-pillar methods. Gypsum is used in the manufacture of wallboard, setting retarders for cement, soil conditioners, Plaster of Paris, food additives and fillers. Potential development areas include: improved wallboard products, cast gypsum products, fillers and fibres in plastics, and specialized cements.

Clays and shales are utilized to produce bricks, flue liners, roofing tile, sewer pipe and expanded aggregate. New product opportunities exist for expanded shale aggregate, fireproofing and waterproof sheeting. Research areas include: stabilization of hazardous wastes and clay geopolymers.

Limestone and dolostone resources provide many stone products. Stone products find use in steelmaking, pulp and paper, waste treatment, chemical processes, cement, building stone and aggregates. Areas of future use exist as neutralizing agents, industrial fillers for the paper industry, calcium metals and de-icing agents.

Silica is used primarily in the production of glass and fibreglass. Potential markets for silica exist in electronics, advanced ceramics, chemical applications, silicon chips, fillers and abrasives. A recent market is the use of colloidal silica in the fine paper industry. Southwestern Ontario has numerous silica sand resources which could provide raw materials for future industrial products.

Continued regional growth is likely to ensure the continued importance of the regions mineral resources and spur research into new products.

PALEOZOIC CARBONATES, SOUTHWESTERN ONTARIO: GEOCHEMICAL CHARACTER RESOURCE POTENTIAL

Feenstra,B.H., Kelly, R.I. Southwestern District, Mines & Minerals Division

Limestone and dolostone resources play an important role in the provinces' industrial economy. Uses are many and varied, including: cement; lime, chemical and metallurgical stone; building stone; pulverized stone; fillers and extenders and crushed stone aggregates.

Within southwestern Ontario the majority of limestone and dolostone resources are derived from three geological horizons. These include: Middle Ordovician Simcoe Group limestones, the Middle Silurian Guelph and Lockport/Amabel Formation dolostones and the Middle Devonian limestones of the Detroit River Group and Dundee Formation.

Although southwestern Ontario has adequate carbonate rock resources to supply most requirements of industry, specialty stone, such as that required by the chemical industry, is becoming increasingly limited. Heightened land use pressures and stringent physical and chemical specifications for stone have made it increasingly difficult to locate favourable resources.

To assist in the identification of potential limestone and dolostone resource areas within southwestern Ontario, a geochemical assessment of the three main geological horizons previously mentioned has been initiated. So as to allow the evaluation of geochemical characteristics for similar geologic units over the widest area possible, rock samples were obtained from a number of sources. These included: quarry sections, natural outcrops and drillcore. Samples were submitted to the geoscience laboratories of the Ontario Geological Survey for analyses. Determinations were made for major elements including Si, Al, Fe, Mg, Na, K, Ca, P, Ti, and Mn. Trace element analyses for Pb, Zn, Ni, Cu, and Cr were conducted for selected samples.

Analysis of geochemical test results provides a number of useful insights including: 1) Identification of potential resource areas which have geochemical characteristics suitable for the various requirements of industry, 2) Providing a better understanding of both vertical and lateral geochemical changes within similar rock formations, and 3)Providing new and updated information on the geochemical characteristics of various rock formations within southwestern Ontario.

METAMORPHIC PETROLOGY AND ALTERATION ASSEMBLAGES OF THE HEMLO GOLD DISTRICT

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The Hemlo-Heron Bay greenstone belt is comprised mainly of metamorphosed volcanic and clastic sedimentary rocks, and is bordered by two granitoid complexes, the Pukaskwa Gneissic Complex to the south and the Gowan Lake Pluton to the north. The clastic metasedimentary rocks are highly immature (in both texture and geochemistry) and have relatively high contents of LREE. The geochemical uniformity of given rock types throughout the stratigraphic section (e.g., greywackes and mafic metavolcanic rocks from both sides of the Hemlo Fault zone, and from the Playter Harbour Group and Heron Bay Group) indicates that the greenstone belt most likely formed in a single tectonic setting (oceanic island arc), rather than by a juxtaposition of suspect terranes.

Detailed field and petrographic observations (including mineral assemblages and textures, xenoliths of deformed country rocks and a narrow contact aureole) reveal that the granodioritic Cedar Lake Pluton has not been affected by the metamorphism recorded in the supracrustal rocks. Therefore, both the local plutonism and formation of the Hemlo gold deposit postdate the peak thermal metamorphism and peak ductile deformation of the region.

Observations on the C zone of the Williams mine, the North zone of the Golden Sceptre Resources property (GSRp), and the Muir zone (which is fault-related to the South zone, GSRp) confirms the association of gold mineralization with sheared rocks. However, gold deposition was probably related to migration of fluids along dilatant structural failures of regional extent. A late calc-silicate alteration (epidote, prehnite), first recognized on the White River exploration property, has been identified at numerous localities within the greenstone belt in the vicinity of the Hemlo deposit. In the main ore zone, this late calc-silicate alteration is indicated by assemblages of epidote, tremolite, titanite, prehnite, pumpellyite, grossular, and armenite.

The Hemlo gold deposit is well known for its enrichment in vanadium, and the presence of a large number of vanadium-rich minerals. Pumpellyite and allanite (with up to 25.7 and 9.1 wt. % V_2O_3, respectively) have been found in green mica schists from the gold deposit. The former represents a new mineral end-member composition for the pumpellyite series: $Ca_8(V,Mg,Fe)_4(V,Al)_8Si_{12}O_{56-n}(OH)_n$, with vanadium as the dominant cation in both X and Y sites. This is the first report of a substantial substitution of vanadium into the allanite structure.

Green mica schists associated with a barite-rich horizon west of Hemlo are characterized by barium-chromium muscovite and barium feldspars of the alkali feldspar-hylophane-celsian series, both different from counterparts in the main ore zone of the Hemlo gold deposit.

OVERBANK SAMPLING IN THE GOULAIS RIVER VALLEY NEAR SEARCHMONT.

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Exciting developments have occurred in geochemical mapping worldwide during the past three years. One of the most interesting has been 'low density sampling' which has been proven to produce valid and effective geochemical maps based on a sample density of one sample per 500 km^2.

Although waters and humus have been used for low density sampling in Scandinavia, the currently preferred sampling medium is 'overbank sampling". Overbank material results from occasional "catastrophic floods" which occur in river channels at infrequent intervals.

In a two day period in August 1989, the writer attempted to locate overbank sampling sites in the Goulais River valley near Sault Ste. Marie. This exhibit shows the results of this test in relation to results obtained from overbank sampling in several European Countries.

RECIONAL GEOCHEMICAL SURVEY: HANES LAKE SHEET

John A.C.Fortescue and E.A.Vida, Geophysics/Geochemistry Section, Ontario Geological Survey

The Hanes Lake Sheet is the second in a new series of regional geochemical maps prepared by the Ontario Geological Survey of the Batchawana greenstone belt, north of Saulte Ste. Marie.

Like the Trout Lake Sheet released at this time last year, the Hanes Lake sheet includes a few geochemical anomalies and several geochemical province patterns some of which are of interest in mineral exploration.

WAWA MINERAL DEPOSITS DATABASE - UPDATE

Frey, E.D. and R.C. Stewart, Ministry of Northern Development and Mines, Wawa

The Wawa Mineral Deposits Database (WMDD) concluded its primary development with an Open File Report (in progress) and the completion of records for 407 mineral deposits in the Wawa Resident Geologist's District.

The WMDD uses DBASE III Plus and Relational Report Writer software to consolidate facts on the geology, production, and location of deposits from older government reports, assessment files, and recent mapping and observations by the Ontario Geological Survey and Wawa Resident Geologist's staff. THE WMDD provides: rapid access to data on specific deposits, a means of exploring geological relationships among deposits, and identification of missing data (within individual deposits or the database as a whole) which may direct further study.

The WMDD contents can be searched, using a DBASE IV program, with up to three parameters chosen from townhsip or area, property status, commodity, mineralogy, host rock, deposit form, metamorphic grade, or alteration minerals. Searches are conducted using whole words or abbreviations. All database records are available in a simplified short form, consisting of 19 data fields. Long form records, containing an additional 45 data fields, are the basis of a continuing program to expand the contents of the WMDD. Nine data fields are memo fields that accept text information of up to 5000 characters each.

The WMDD records also have been linked with digitized base maps by QUIKmap software, allowing on-screen access to the database records directly from location maps.

MINERAL POTENTIAL OF THE MAFIC TO ULTRAMAFIC ROCKS IN THE MUSKOKA-PARRY SOUND AREA OF THE CENTRAL GNEISS BELT, GRENVILLE PROVINCE, ONTARIO

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In the Muskoka-Parry Sound area there are approximately 100 reported occurrences of base and/or precious metals, many of which underwent exploration earlier in the century. This project was designed to investigate the localized geology and economic potential of a selection of these occurrences. The mineralization can be grouped into three types; 1) copper-gold mineralization in quartz veins within gabbroic rocks, 2) copper-nickel and copper-zinc mineralization in the contact zone between a mafic and felsic gneiss, and 3) sulphides (pyrite, pyrrhotite, chalcopyrite) in gabbro, norite, pyroxenite, or peridotite pods within the gneisses. Occurrences of type 1 and 2 are found in the Parry Sound area, in the Parry Sound structural domain, and those of type 3 are found in the Muskoka area, in several different structural domains. Occurrences of types 1 and 2 produced gold and copper in the early part of this century, and have some potential today in that there are still large areas unmapped and untested. Occurrences of type 3 tend to consist of nickel sulphides, and most underwent exploration in the mid part of the century. Potential is difficult to determine because of the pod-like nature of the host rock, and although massive, the small volume of sulphide.

AGGREGATE RESOURCES OF THE MOOSONEE AREA, NORTHEASTERN ONTARIO.

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During the summer of 1990, a detailed investigation was undertaken by the Ontario Geological Survey to delineate the aggregate resources within the Moosonee area. The area studied included Moose and Horden geographic townships, Rabbit Ridge and the river bars between the mouth of the Kwetabohigan River and James Bay. This project is part of the ongoing Aggregate Resources Inventory Program. The quality and quantity of the sand and gravel and bedrock will be determined for direct use in both road-building and general construction applications. This information is required for the evaluation of aggregate resources development potential and for land use planning decisions.

The sand and gravel resources in Moose and Horden geographic townships are considered to be limited. The Rabbit Ridge area is an exception as it contains locally significant beach deposits consisting of material ranging from sand to coarse crushable gravel. Medium to coarse sand and fine gravel is dredged from the river bars located between Moosonee and Moose Factory Island. The limestone bedrock of the Devonian Kwataboahegan Formation is an alternative source of aggregate within the study area. A wide range of crushed stone products have been produced from the Labelle quarry, located within Horden geographic township. Results of this study will be presented in the form of an Open File Report with 2 maps at a scale of 1:50 000.

A MODIFICATION OF THE SHALLOW REFLECTION SEISMIC TECHNIQUE FOR APPLICATION IN SOUTHERN ONTARIO

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The shallow reflection seismic technique is a fairly new geophysical surveying method for mapping overburden stratigraphy and bedrock topography in glaciated regions. It is most successful when conducted in areas having fine-grained, water saturated surface sediments. With a veneer of glacial till often overlying extensive gravel sequences, conditions in southern Ontario are less than favourable for this technique to be successfully applied. This study examines the various facets of the shallow reflection seismic technique to adapt it for the conditions encountered in southern Ontario.

A preliminary survey was conducted just north of Toronto, using the standard common offset technique. This section will be used as a reference section. The same line will be resurveyed in 1991, using a modified technique as determined by this study. A comparison between this section and the new section will determine how much improvement the modified technique provides. The focus of the study to date has been on modifying field techniques; data processing will be examined in the coming year. The emphasis this past field season has been of examination of the shotgun shell source, the gun, and the coupling of the gun to the ground.

Different shotshell loads were examined for energy level and frequency content. A comparison of energy levels and frequency spectra for each load will be presented. A smokeless-black powder mixture provided the optimum signal. Different gun designs have been constructed and will be tested this fall in a deep lake along with several models currently used by local consultants. Results will be presented in the form of power spectra.

In order to test guns on land, and to examine the problem of coupling, a series of standard shot holes have been developed on the Waterloo campus. These are intended to allow the comparison of repeated shots from the same hole, and to examine the importance of shot depth, receiver depth, and source type on the signal received on a geophone array.

LEAD ISOTOPE INVESTIGATIONS BEARING ON THE SOURCE OF GOLD AND OTHER MINERALIZATION IN THE RED LAKE AREA

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The problems of timing and source of gold and sulphide mineralization have been addressed in the Red Lake area from 300 Pb isotope analyses on >250 samples of sulphides, oxides, gold and potential source rocks.

Sulphides from the Campbell/Dickenson mines give an apparent Pb-Pb age of 3040 ± 60 Ma comparable to a mafic host rock age of 3070 ± 30 Ma and felsic rocks dating 2980 ± 40 Ma. These Pb-Pb ages compare with precise U-Pb zircon ages ranging from 2964 to 2992 Ma in the felsic metavolcanics. A somewhat younger Pb-Pb age of 2865 ± 10 Ma is obtained from minor mineralization from the west part of the Red Lake greenstone belt, while sulphides and gold from McFinley, Cochenour Willans and Abino mines gives an apparent Pb-Pb age of 2810 ± 30 Ma.

Sulphides from deposits in the Flat Lake-Howey Bay deformation zone exhibit variable isotopic patterns that contrast with the composition and age of their host rocks. Madsen and Starratt-Olsen sulphides hosted by old metavolcanics have apparent ages of 2800 Ma. In contrast, Buffalo and Hasaga sulphides hosted by late felsic intrusions have poorly defined apparent ages of 2900 ± 100 Ma.

A combined age of 2830 ± 20 Ma for mafic metavolcanics and metasediments from McKenzie Island agrees with a zircon U-Pb age from a felsic tuff on the same island.

Younger sulphide mineralization from across the greenstone belt with uniform $^{206}Pb/Pb^{204}$ values of 13.4 to 13.5 give calculated "model ages" of 2700 to 2730 Ma.

Magnetites from late widespread felsic intrusions yield young ages of 2660 ± 10 Ma, precluding a genetic connection of the felsic intrusions with gold mineralization.

The Pb isotope data from gold samples reveal complex isotope patterns. Part of the lead had a source with unusually high $^{207}Pb/Pb^{204}$ values indicating either a highly evolved 3 Ga source or maturation of Pb prior to extraction in a 2.7 Ga mineralizing event.

The linearity of Pb isotope data for old deposits precludes a single late gold event. Gold may be associated with all three episodes of volcanism as well as plutonism.

REGIONAL GRAVITY FIELD IN THE ABITIBI AREA

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A graphical method was employed to separate the Bouguer anomaly field into its regional and residual components. Smoothly varying regional base levels were fitted to Bouguer anomalies along 21 north-south and 30 east-west Bouguer profiles. These profiles were drawn at a distance of 7 km apart.

The graphically prepared regional field in the study area is characterized by alternating regional gravity highs and lows with a strong north-south trend. This trend however, disappears in the centre of the map area where a prominent east-west trending zone is apparent. This easterly-trending zone is possibly the location of a major crustal block boundary zone which, at the surface, is spatially associated with the downward extension of the Destor-Porcupine Fault Zone (DPFZ).

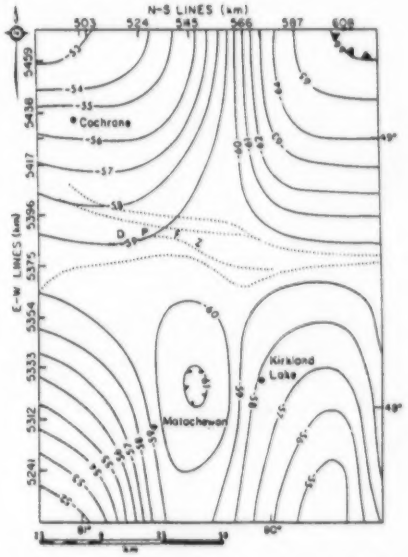

Figure 1. Regional gravity map of the Abitibi area. Superimposed upon the deep level east-trending regional field is the location of the DPFZ at the surface. Contour interval is 1 mgal. The location of some of the N-S and E-W Bouguer gravity profiles are also shown.

GEOLOGICAL AND STRUCTURAL INTERPRETATION OF REMOTE SENSING AND HIGH RESOLUTION AEROMAGNETIC DATA FOR THE MISSINABIE - RENABIE AREA

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A structural interpretation of airborne C-band radar (SAR), LANDSAT Thematic Mapper (TM), 1:50 000 scale airphoto mosaic and high resolution total field aeromagnetic data was conducted over the Missinabie - Renabie area northeast of Wawa, Ontario. Preliminary results from this investigation indicate that many of the regional features interpreted from the remote sensing and aeromagnetic data are large scale manifestations of regional foliation trends and high strain zones that had previously been mapped, while others are previously unidentified structures.

The procedures for data acquisition and analysis have been adapted from work previously conducted by the authors. All of the data sets (SAR, TM, aeromagnetic) with the exception of the airphoto mosaic are in digital format which allowed: 1) selective enhancements to accentuate specific details, 2) superposition of data sets, and 3) viewing of merged or separate images.

The interpretation process involved the identification and mapping of all linear, curvilinear, semicircular or other pronounced geomorphic and bedrock structures on each of the data sets. A field program of "ground-truthing" was carried out to verify the presence, possible cause and potential geological importance of the geomorphic features. Outcrops as near as possible to these features were visited and lithological and structural data (e.g., brittle fractures, foliation orientations) were systematically recorded.

This study has shown that remote sensing, used in conjunction with other data sets, can be used to identify geologically important features such as faults, high-strain zones, regional foliation trends and intrusions. More generally it has illustrated the usefulness of remote sensing in understanding the 'regional' geology and structure of a given area. More importantly, it emphasizes the advantages and abilities of each type of remote sensing data, and also demonstrates that the maximum amount of information is gained by integrating all of the remotely sensed data sets.

INDUSTRIAL MINERAL POTENTIAL IN THE MANITOUWADGE AREA

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In the past, mineral exploration in the Manitouwadge area has been focused on the search for base and precious metals. With the increased interest in Industrial Mineral commodities, a new range of exploration targets have been realised. This project has initiated an inventory of known Industrial Mineral commodities and sites of high potential, within a 50 km. radius of the town of Manitouwadge.

Numerous field visits were conducted and sampling was undertaken to develop a suite of rocks representing the potential Industrial Mineral occurrences of the area. Commodities observed and known to occur in the area included dimension and decorative stone, garnet, sillimanite, anthophyllite, flake graphite, muscovite, wollastonite, barite, rare-earth minerals and cordierite.

Efforts to inform the exploration industry, prospectors and the public of the potential in the area, will include information seminars, poster displays, and a write-up in the Annual Report of the Schreiber-Hemlo Resident Geologist.

STRUCTURAL GEOLOGY OF THE MIDLOTHIAN LAKE - PETERLONG LAKE AREA, ABITIBI GREENSTONE BELT, SUPERIOR PROVINCE

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The Midlothian Lake-Peterlong Lake area is located in the Abitibi Greenstone Belt south of Timmins and west of Matachewan and includes approximately twelve townships. Part of the study has concentrated on the evaluation of the stratigraphic and structural relationships between distinctly different metavolcanic packages in two important areas.

In the north-central part of the area, a large syncline occupying most of Zavitz Township is cored by rocks interpreted to be Mg- and Fe-tholeiitic metavolcanic rocks based on field criteria developed for the Kirkland Lake and Timmins area. This syncline is flanked to the northeast, in English Township, by a thick, southeast-facing sequence of intermediate to felsic volcanic rocks interpreted to have a calc-alkaline affinity. A much thinner unit to the south of the syncline has a very similar composition.

The second important group of rocks occupies the southern part of the area in Sothman, Halliday and Midlothian townships. These rocks are a sequence of calc-alkaline, intermediate to felsic, massive volcanics and fragmental rocks and calc-alkaline, mafic, massive and pillowed volcanic rocks, which have previously been called the Halliday Dome. The central part of the area in Semple and Hutt townships is dominated by a folded sequence of tholeiitic metavolcanic rocks.

Previous stratigraphic subdivisions have grouped all the calc-alkaline metavolcanic rocks into an older package called the Upper Formation of the Deloro Group and all the tholeiitic metavolcanic rocks into a younger sequence called the Lower and Middle Formations of the Tisdale Group.

The contact between the calc-alkaline and tholeiitic units in English and Zavitz townships is very sharp and is marked by a zone of high strain which follows the contact around a regional gently northeast-plunging syncline. This suggests that an early fault existed between the calc-alkaline rocks at the flanks, and the tholeiitic rocks occupying the core of the syncline. The tholeiitic rocks are therefore structurally overlying the calc-alkaline rocks, making the original stratigraphic relationship between the two units unclear.

In contrast, the contact between the tholeiitic rocks in the central part of the area and the calc-alkaline rocks in Halliday Township is gradational across a number of units whose chemical affinity could not be determined on the basis of the field criteria. Significant zones of high strain were not identified along this contact. The tholeiitic volcanic rocks face south near the contact, and all stratigraphic younging directions within the southern part of the area indicate that the entire calc-alkaline sequence youngs to the south as well. This suggests that the calc-alkaline rocks of the Halliday Dome are younger than the tholeiitic rocks immediately to the north and that the previous stratigraphic correlations need to be revised.

OPAP FUNDED BASE METAL DISCOVERY IN THE NORTH SWAYZE AREA.

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Prospectors R. Denommee, D. Morin, G. Ross and F. Ross combined their 1990 OPAP grants under a partnership agreement to facilitate evaluation of several claim groups in the Swayze area. Most of their planned work projects had been completed when, in early September, 1990, the partners decided to stake a gossan zone exposed during forest access road building in 1985. A trench was subsequently blasted through the gossan cap, exposing a recrystallized, siliceous fragmental unit with a pyrrhotite-graphite-chalcopyrite matrix. Localized concentrations of sphalerite were also observed. Prospecting along trend revealed the presence of similar style mineralization over a 700m strike length, both in siliceous fragmental units and banded, siliceous cherty tuff/massive pyrrhotite+ chalcopyrite units. On October 4, 1990, the Ministry of Northern Development and Mines released the results of an airborne Electromagnetic and Magnetic Survey of the North Swayze - Montcalm area, which covered the area of the new prospect. The survey outlined a 1700m long electro-magnetic anomaly coincident with the prospect. The OPAP funded ground work, combined with the geophysical data derived from the airborne survey, enhanced the value of the property to the extent that the 33-claim group was optioned to Asarco Exploration Company of Canada Limited. Preliminary evaluation of the property is ongoing.

SUPRACRUSTAL ASSEMBLAGES AND STRUCTURE OF THE LATE ARCHEAN SOUTHERN ABITIBI GREENSTONE BELT NEAR LARDER LAKE

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Structural and stratigraphic relationships of supracrustal assemblages remain outstanding problems in the understanding of the geological history and mineralization of the Abitibi Greenstone Belt. During 1990, the metavolcanic-dominated McElroy and Larder Lake assemblages and the metasedimentary-dominated Hearst and Timiskaming assemblages were studied. The homoclinal NE-facing McElroy assemblage is dominated by massive mafic rocks, pillowed basalt, plagioclase-glomerophric units, ultramafic rocks, and felsic fragmental rocks. The multiply folded and faulted Larder Lake assemblage consists mostly of pillowed mafic rocks and komatiite. The assemblage does not contain plagioclase-glomerophyric units and contains only minor felsic metavolcanic units. These two assemblages, and their contrasting structural styles, are separated by the south-side-up (?), steeply dipping, Lincoln-Nipissing shear zone. This shear zone also defines the southern limit of turbidite facies metasedimentary rocks of the Hearst assemblage which rests stratigraphically above the earlier-deformed Larder Lake assemblage. Detrital sources for the Hearst assemblage included the Skead and McElroy and/or Larder Lake assemblages. Alluvial-fluvial facies metasedimentary rocks of the Timiskaming assemblage lie unconformably above the earlier-deformed metavolcanic Kinojevis assemblage and are overthrust by the more southerly Larder Lake and Hearst assemblages along the Cadillac-Larder shear zone. Source material, sedimentary facies, and the presence (Timiskaming) or absence (Hearst) of alkalic metavolcanic rocks suggests two scenarios in relating the metasedimentary assemblages: (1) the Timiskaming and Hearst assemblages could represent deposits of different, late-tectonic basins; 2) the Hearst assemblage could represent early and distal deposits, whilst the Timiskaming assemblage could represent later and proximal deposits of the same basin. In either case the assemblages were later juxtaposed.

Emplacement of the Round Lake Batholith deflected metavolcanic units prior to deposition of the metasedimentary assemblages. NW-striking folds and faults post-dated deposition of the Hearst assemblage and the emplacement of at least some alkaline intrusions (e.g. McElroy Stock). NE-striking folds and faults and finally N-striking (NNW to NNE) folds and faults post-dated the NW-striking structures. In post-Archean time, NNE-striking structures in the Proterozoic Huronian Supergroup formed and may reflect reactivation of underlying Archean basement structure.

Most large gold deposits in the area are located near the intersection of late NE-striking and/or ENE-striking shear zones with the Cadillac-Larder shear zone. Away from this shear zone, smaller gold deposits are located near late ENE-, NE-, NNE-, and NW-striking shear zones.

GEOLOGY OF THE WEST HALF OF THE KIRKLAND LAKE AREA, DISTRICT OF TIMISKAMING

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The west half of the Kirkland Lake map area is a 535 km^2 area located 20 km west of Kirkland Lake. It includes the townships of Terry, Lee, Bompas, Dunmore, Holmes, Burt and parts of Maisonville, Grenfel, Eby, Flavell and Gross townships.

The Archean rocks are metavolcanic and metasedimentary rocks intruded by granitoid stocks and diabase dikes. These rocks are unconformably overlain by the Gowganda Formation of the Cobalt Group. The Kirkland Lake-Larder Lake Fault Zone (KLFZ) transects the south part of the area.

The oldest volcanic rocks are the north-facing Pacaud Tuffs comprised of calc-alkalic andesite, dacite and rhyolite tuff, and tuff breccia located in the southeast corner of Burt Township. Here, they are truncated by the gneissic tonalitic rocks of the Round Lake Batholith to the south and by granodiorite to the east. The tuffs thin westwards and upwards, where they become interlayered by tholeiitic basalt flows, iron formation and metasedimentary rocks. The overlying tholeiitic flows are Mg-rich and Fe-rich basalts of the Catherine Group.

Calc-alkalic andesite tuffs and tuff-breccias of the Skead Group extend into the east central part of Burt Township and become overlain by rocks of the Gowganda.

The Mg-rich and Fe-rich tholeiitic basalts north of the KLFZ in Lee, Bompas, Maisonville and Grenfel townships are part of the Kinojevis Group.

Timiskaming alkalic metavolcanic and metasedimentary rocks occur along the KLFZ in Eby and Holmes Townships. The metavolcanic rocks are mainly flows, flow breccias and tuff-breccias. They have a more mafic composition in Holmes Township than in Eby Township. The interlayered sedimentary rocks are arkoses, siltstones and conglomerates, some of which contain boulders of gneissic tonalite.

A sill of anorthositic gabbro occurs in the south east corner of Holmes Township. In places, alternating feldspar and mafic mineral layers are present.

The granitoid rocks of the Round Lake Batholith are gneissic tonalite. Other batholiths, stocks and dikes consist of equigranular to porphyritic granodiorite, monzonite and syenite. Mafic alkalic phases of these rocks are mainly hybrid rocks formed during the emplacement of the rocks into the mafic volcanic rocks.

The Gowganda Formation forms a north-striking, shallow dipping synclinal sedimentary sequence north of the KLFZ. Along the KLFZ, soft sedimentary deformations, quartz-veining and shears show that the KLFZ was active during and subsequent to the deposition of the Gowganda Formation.

Gold mineralization occurs in the syenites, and altered metavolcanic and metasedimentary rocks in the south part of Holmes Township

GEOLOGY OF THE WHISKEY LAKE GREENSTONE BELT, DISTRICTS OF ALGOMA AND SUDBURY

Jensen, L.S., Precambrian Geology Section, Ontario Geological Survey

The Whiskey Lake Greenstone Belt is a 40 km long arcuate, belt centred approximately 25 km west of Elliot Lake. It is bounded to the north by Proterozoic sedimentary rocks of the Quirke Syncline, and to the south and east by granitoid rocks of Archean and Proterozoic age.

The greenstone belt consists of komatiitic, tholeiitic, and calc-alkalic metavolcanic rocks cut by metamorphosed, subvolcanic, calc-alkalic, porphyritic dikes and sills. In places, interflow metasedimentary rocks, that include banded iron formation, chert, wacke and siltstone, occur with the metavolcanic rocks. The calc-alkalic rocks represent a mineralized, felsic volcanic domal complex that was built on a tholeiitic basalt platform. Strong silicification, epidotization, sulphidization and quartz-veining is present in the domal complex.

The Archean granitoid rocks are mainly gneissic to massive tonalites, intruded by trondhjemites, in turn intruded by fine-grained to megacrystic granodiorite and quartz monzonite.

Proterozoic rocks of the Huronian Supergroup unconformably overlie the Archean rocks. The basal rocks of the Supergroup comprise tholeiitic volcanic rocks of the Thessalon Formation underlain in places by a thin boulder conglomerate. The uranium-bearing Matinenda Formation of the Elliot Lake Group overlies the Thessalon Formation.

Archean to Proterozoic, mostly post-Huronian, mafic intrusive rock occurs in the area as gabbro sills and diabase dikes

Archean deformation events include folding and faulting prior to, during and subsequent to the emplacement of the granitoid rocks. The last event allowed for the formation of deeply eroded scarps in the Proterozoic topgraphy and their subsequent filling by Proterozoic Thesselon volcanic rocks on which the remaining Huronian Supergroup was deposited. Proterozoic deformation includes folding, thrust faulting and normal faulting that occurred concurrent with late mafic magmatic events.

Favourable geological features for base, precious and platinoid metal exploration include the presence of a felsic volcanic centre, sulphide-bearing iron formation and mafic intrusive rocks, altered rocks along shear zones, and detrital sulphide-bearing conglomerates in the Huronian Supergroup.

TWO MAFIC METAVOLCANIC-DOMINATED ASSEMBLAGES OF THE ABITIBI GREENSTONE BELT; THE McELROY AND LARDER LAKE ASSEMBLAGES.

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S.L. Jackson, Geologist, Ontario Geological Survey

The Lincoln Nipissing shear zone separates two metavolcanic-dominated assemblages, the McElroy assemblage to the south and the Larder Lake assemblage to the north. The aim of this study is, by using field, petrographic, and geochemical criteria, to determine if the two assemblages are related. Field-based results are presented in this poster display.

The McElroy assemblage is a northeast-facing homoclinal sequence of mafic metavolcanic rocks, gabbro, intermediate to felsic metavolcnic rocks, and minor ultramafic rocks. Pillowed and massive units commonly grade into one another and both are commonly plagioclase-glomerophyric. A main component of the McElroy assemblage is hornblende gabbro that grades northwards into leuco-gabbro (50-70% plagioclase) and pyroxene gabbro (30-40% plagioclase). The hornblende gabbro consists of ~40-60% plagioclase and 20-30% hornblende. The hornblende crystals form distinctive dendritic aggregates that branch stratigraphically downwards. Locally the dendritic patterns closely resemble pyroxene-spinifex texture. Intermediate to felsic metavolcanic rocks (crystal-tuff, lapilli-tuff, and tuff-breccia) and debris flows are interlayered and/or interbedded with the mafic metavolcanic and gabbroic rocks. A serpentinized peridotite unit that crops out just south of the Lincoln-Nipissing shear zone is tentatively included with the McElroy assemblage. Units of the McElroy assemblage are NW-striking and relatively uncomplicated by folding.

The Larder Lake assemblage displays more complicated folding and faulting pattern than the homoclinal McElroy assemblage. Larder Lake assemblage units are, therefore, of more irregular distribution. This assemblage consists mainly of Mg-rich and Fe-rich pillowed basalt and komatiite. In contrast to the McElroy assemblage, the Larder Lake assemblage does not contain plagioclase-glomerophyric units and contains only minor gabbroic and intermediate to felsic metavolcanic rocks.

Future studies will document the petrography and geochemistry of units from the two assemblages to further constrain their relationship to one another.

THE FIRST MINING DEVELOPMENT IN THE RED LAKE AREA - THE HOWEY GOLD MINES

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Lorne Howey prospected and discovered the Howey Gold Mines after reading the 1924 report on the Geology of the Basin of Red Lake by Dr. E. L. Bruce from the Ontario Department of Mines. Atfer recording the claims, Lorne contacted mine promoter John E. Hammell, who then formed the Howey Red Lake Gold Syndicate in 1926.

On April 7, 1926, the first diamond drilling outfit arrived in Red Lake and began drilling at the Howey. The following year shaft sinking commenced and a headframe was built. On April 2, 1930 the mill commenced operations with the first gold brick being poured on May 14, 1930. The first manager of the Howey Mine was Horace Greely Young. The Howey turned out to be the lowest grade of any of the mines in the Red Lake camp. By using a modified shrinkage system and hand sorting of the ore kept costs down and made the Howey a profitable venture.

It was during the 1925-1926 Red Lake rush, partly due to its remoteness from Hudson, the nearest railhead, located 200 miles by land route to the southeast, that commercial aircraft transportation came into its own. Air transportation using float equipped planes became the main supplier to the bustling camp, and in its start-up days, Red Lake had the busiest volume of aircraft traffic in the world.

Just when the Howey ore body was nearly exhausted, the crown pillar collapsed and the mine ceased operations on November 3, 1941.

GEOLOGICAL DATA INVENTORY FOLIOS, WAWA DISTRICT

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Compilation of Geological Data Inventory Folios (GDIFs) continued in 1990, supported by the Northern Development Fund (Wawa Economic Development Initiatives). Priority was given to updating areas and townships with high exploration activity and/or gold potential, primarily in the Mishibishu Lake area and in the Missinaibi Lake area.

Geological Data Inventory Folios consist of a detailed index of the exploration data available in the assessment files of the Wawa Resident Geologist's Office. Information is provided both in a text format and on base maps. Currently, the Wawa office enters the text information into a database computer program, while the map information is drafted by hand. Updated copies of the GDIFs are produced directly from the database files onto a laser printer.

A total of 67 Geological Data Inventory Folios are available for viewing or purchase at the Wawa Resident Geologist's Office. Of these, 20 are available in published form, with the remaining unpublished GDIFs being offered for the cost of photocopying.

TECTONIC RELATIONS AMONG PARRY SOUND DOMAIN AND SEGUIN AND ROSSEAU SUBDOMAINS, SOUTHWESTERN GRENVILLE PROVINCE

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Near Orrville, Ontario, in the southwestern part of the Central Gneiss Belt (Grenville structural province), a triple junction occurs between three lithotectonic domains thought to be remnants of crustal slices thrust northwestward during tectonic activity associated with the Grenville Orogeny. Here, granulite-facies gneisses of Parry Sound domain lie sandwiched between amphibolite-facies gneisses of Rosseau and Seguin subdomains. We are presently mapping this area in order to test the general model of northwest-directed thrusting, and to investigate mechanisms of deformation in these deep-crustal rocks.

Kinematic indicators show that rocks of Parry Sound domain have been thrust westward over a structural basement represented by highly migmatitic orthogneiss of Rosseau subdomain. The tectonite zone between them is narrow and clearly defined: easily recognized granulites of Parry Sound domain lie in juxtaposition with more homogeneous amphibolite-facies migmatites of Rosseau subdomain. An intriguing structural problem arises from the fact that stretching lineations in the margin of Parry Sound domain are oriented parallel to the west-trending boundary, while those in the adjacent Rosseau subdomain are oriented approximately normal to it.

The boundary between Parry Sound domain and Seguin subdomain is wide and complex. The most prominent zones of high strain, visible as major lineaments on air photos and suggested by A. Davidson and coworkers to represent the boundary of Seguin subdomain, dissipate within Parry Sound domain, and appear to be northwest-directed splays rooted in the basal shear zone of Seguin subdomain. Within the bounding tectonite zone of Seguin subdomain at least four phases of deformation are recognized: 1) northwest-directed thrusting of the subdomain producing the basal shear zone and producing the splays in underlying Parry Sound domain; 2) southeast-directed normal-sense shearing, affecting just part of the boundary zone; 3) widespread minor upright folding about east-trending axes; and 4) attenuation of certain fold limbs into minor east-west striking, vertically dipping strike-slip shears, indicative of renewed west-directed transport of Seguin subdomain.

Late chlorite- and epidote-bearing brittle fracture zones occur throughout the area map area.

Discoveries of possible economic interest are new areas underlain by calcitic and dolomitic marble, several bodies of regularly jointed granitoid gneiss with potential for building stone production, and an extensive rock unit of probable volcaniclastic origin with potential for gold exploration.

GEOCHEMICAL TRENDS AFFECTING OVERBURDEN EXPLORATION IN THE MATHESON AREA

McClenaghan, M.B., Engineering and Terrain Geology Section, Ontario Geological Survey

Between 1984 and 1989, the Ontario Geological Survey completed a regional overburden sampling and geochemistry program in the Black River-Matheson (BRiM) area of northeastern Ontario.

Two hundred and eighty-two surface samples of Matheson Till were collected from backhoe trenches in areas of shallow overburden. Regional dispersal trends are readily discernable for the compositional data. Major oxides, non-magnetic heavy minerals and pebble lithologies display southeastward deceases in abundance and reflect changes in bedrock lithologies. Trace element geochemistry and gold grain abundances display local dispersal trends related to bedrock mineralization. Five areas of interest have been identified based on their anomalous concentrations of Au, Cu, Co, Ni and Zn.

Due to the weathered/oxidized nature of surface till samples and variable distribution of Au in the fine and non-magnetic heavy mineral concentrates, both fractions should be used for Au and base metal exploration in the region.

In areas of thicker drift, 1456 overburden samples were collected from 225 rotasonic drill holes. Areas of interest have been identified based on anomalous trace element associations similar to those for surface till samples.

GEOLOGICAL MAP OF PART OF MADOC TOWNSHIP, SOUTHEASTERN ONTARIO

Meyn, H.D., Regional Specialist, Bancroft.

Field work in 1989 and 1990 for an ongoing study of the stratigraphy and sedimentation of the metasedimentary rocks of the Grenville Supergroup in southeastern Ontario was concentrated in the east central part of Madoc Township and this map shows the results.

The conglomerates, arenites, and mudstones exposed immediately southwest of Hazzard Lake are now identified as turbidites. Several facies of turbidites are present but exposure is inadequate to map them out. Facing directions in these rocks are southerly and southwesterly.

In the vicinity of Rimington, ripple cross-laminations are preserved in fine- to very fine-grained calc-arenites (marbles) that indicate paleocurrents were, in a general way, from east to west.

MINERAL DEPOSITS IN GRENVILLE MARBLES, SOUTHEASTERN ONTARIO

Meyn, H.D., Regional Specialist, Bancroft.

Fell, K.E., Research Assistant, Bancroft.

Martin, C.B., Student Assistant, Bancroft.

Since the middle of the 19th century the carbonate rocks of the Grenville Province of Ontario have made a substantial contribution to the mineral production of Ontario. A total of 638 mineral deposits (146 past producers, 12 active producers) are currently on record as being hosted by Grenville marbles. Of these, 329 are marble (80 past producers, 9 active producers); 94 iron (35 past producers); 64 graphite (6 past producers); 60 non-ferrous metals and metal sulphides (8 past producers, 1 active producer); 46 fibrous fillers (talc, tremolite, wollastonite, actinolite, asbestos, and brucite) (6 past producers, 2 active producers); 28 mica (7 past producers); and 17 miscellaneous (apatite, barite, serpentine, and mineral specimens) (17 past producers).

MICROEARTHQUAKE MONITORING IN THE WESTERN LAKE ONTARIO REGION, A PROGRESS REPORT.

Mohajer, A.A., R. McGrory, and H.C. Halls. Department of Geological Sciences, University of Toronto, Erindale College, Mississauga

Two digital seismographic stations became operational in the western Lake Ontario region since April, 1990 with the third one imminent. The purpose for deployment of these sensitive seismic recording devices is to examine the level of microearthquake activity (M<3), below the detection threshold of the GSC's standard seismic stations in this region. These small earthquakes have been frequently felt by local residents and can reveal useful information on the seismogenic sources. These data are crucial to more realistic seismic hazard assessments for critical facilities and other important buildings in the western Lake Ontario region.

Instruments used are two SCINTREX, PRS-4 digital recorders, one with 3-component, 2Hz, L-4C Mark Products seismometers at a farm near Rockton, Cambridge, and the other station with a single component seismometer at Mt. Nemo Conservation Park, 10 km north of Burlington. The sensors at both stations are located on Limestone bedrock of Lockport and Guelph Formations. Instruments were operated in the trigger mode with threshold setting of 4 for STA/LTA ratio (Short Term Average/Long Term Average of trace amplitudes of the background noise with respect to signal). An average number of the triggered events were 70 and 60 per month for Mt. Nemo and Rockton stations respectively. About 5% are false triggers due to local animal activity, 80% from known quarry blasts, and the remainder are unidentified events either cultural or natural. Most of these events occurred at times outside of quarry blasting schedules. Typical quarry blast response spectra show that 90% of the energy, E , is carried in the frequency band 4 to 12 Hz. Similar observations for potential earthquakes show E is carried dominantly within the 2 to 8 Hz range. Events as small as M_L=1, were commonly recorded at both stations which are about 40 km apart. S-P times indicate that our network can record M≥1 events at distances up to 50 km.

Pattern recognition and response spectra were used to discriminate between natural events and unscheduled blasts during the day times.

QUATERNARY GEOLOGY, WAWA AREA, NORTHERN ONTARIO.

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The earliest glacial flow in the Wawa area is recorded by striae, ice moulded bedrock, glacial grooves, chatter marks and rattails. These features indicate a regional southwesterly flow unaffected by bedrock topography. A younger set of striae cross-cuts the older set indicating a later westward flow controlled by bedrock topography. A thin till was deposited by these two flow events.

Basal meltwater initially drained to the southwest as indicated by "P" Forms preserved on the surface of bedrock highlands. A later flow of basal meltwater drained westward through bedrock valleys as indicated by a second set of "P" Forms.

Glacial outwash systems formed within the Molybdenite, Dore, Catfish, Magpie, Firesand and Hawk Junction river valleys and within the Grant Lake and Wawa-Manitowick Lake Troughs. Two deltas (built into Glacial Lake Minong) formed in the Dore River Valley and the Wawa-Manitowick Lake Trough.

Three minor moraine fragments were identified within the Dore and Magpie river systems and the Wawa-Manitowick Lake Trough. These moraines were likely formed by minor ice advances. Areas of ice were left stranded on bedrock highlands during deglaciation. Dead-ice topography and coarse alluvial fans formed when these stranded areas of ice melted.

SUDBURY GEOLOGY - DIGITAL COMPOSITING

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The Sudbury Geological Compilation Map (Map 2491, Dressler 1984) produced by the Ontario Geological Survey is the subject of an experiment in digitization and integration with remote sensing data. The object of the experiment is to make the map available for analysis in a digital geographic data base and for comparative image processing operations.

The Sudbury map was initially laser scanned generating a raster file that was subsequently converted to vector form and edited using geographic information system (GIS) software. Synthetic Aperture Radar (SAR) data flown by the Canada Centre for Remote Sensing, Radar Data Development Program was merged with the geological data base using image analysis system (IAS) software. The IAS was also used to enhance the SAR data, as well as to create the SAR plus geology composite.

This composite was particularly useful for the direct comparison of geological data, largely based on outcrop sampling, with radar data, a tool used primarily for the mapping of surface morphology. Features of note include the strong correlation of numerous regionally mapped structures with surface morphology. In fact, the SAR data shows that many of the mapped structures (e.g., diabase dikes and faults) are extendable or could be connected to other mapped structures.

The surface morphology as represented in the SAR data also illustrates the resistive character, texture and orientation preference of the various lithological units. For example, the extent and distribution of the Sudbury Igneous Complex and the Onaping Formation are well defined as topographic features. Their topographic expression is also unique in the North and South Range. Most remarkable is an apparent texture within and parallel to the Lower Zone of the North Range.

These observed features will be thoroughly investigated in the field in the spring of 1991.

The structure of such a digital data base permits the interchange and subsequent enhancement and analysis of various data sets, including other remote sensing data or geophysical data. As well, the data base can be continually updated as new information becomes available.

EXPLORATION AND MINING ACTIVITY IN NORTHWESTERN ONTARIO

O' Brien, M. S., Resource Geologist, Northwestern Region.

The mineral sector in Ontario provided 24,682 direct jobs and produced products with a total Canadian dollar value of $7,171,883,000 in 1989.

The top 4 gold producers in Canada in 1989 were from Northwestern Ontario: Williams Mine (494,127 oz), Golden Giant Mine (378,400 oz), David Bell Mine (312,190 oz), and Campbell Mine (267,876 oz).

This poster displays the producing mines and advanced mineral exploration projects in the Northwestern Region of the Province of Ontario. Currently there are 7 producing gold mines, 4 base metal mines, 6 stone quarries, and 5 seasonal amethyst mines in the region employing 2147, 1133, 26 and 32 people respectively. There are also 24 projects in advanced exploration. In 1989, the region produced approximately: 57,101 kg (kilograms) of gold; 117,947 kg of silver; 40,504,694 kg of copper; 18,211,733 kg of nickel; 4,572,288 kg of lead; and 130,755,967 kg of zinc - for a total Canadian dollar value of $1,466,054,949. Representative ore samples of Northwestern Ontario are also on display.

A statistical summary booklet that tabulates regional data such as reserves, grades, location, ownership and development is available free of charge.

MINERAL POTENTIAL STUDIES OF MAFIC AND ULTRAMAFIC INTRUSIVE ROCKS IN THE ELLIOT LAKE AREA

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R.S. James, Professor, Department of Geology, Laurentian University, Sudbury, Ontario

To assess the PGE, Au, Ni and Cu potential of mafic and ultramafic intrusions in the Elliot Lake area, a four-year geological and lithogeochemical program, funded by the Ministry of Northern Development and Mines, has been initiated.

Detailed lithogeochemical sampling and preliminary investigations of Cu-Ni sulphide occurrences in the East Bull Lake (EBL) gabbro-anorthosite intrusion were completed during the 1990 field season. This intrusion is one of several Early Proterozoic mafic plutons occurring within the southernmost part of the Superior Province in the Elliot Lake - Espanola region. Both the EBL intrusion and the larger Shakespeare-Dunlop intrusion, located 15 km to the east of East Bull Lake, are currently being explored for platinum-group elements (PGE), Cu and Ni. The former is a 800 m thick lopolith which crops out over an area of approximately 50km^2. It comprises variably metamorphosed, layered plagioclase-, augite-hypersthene- and olivine-bearing cumulates. A suite of 500 samples was collected from throughout the intrusion, and represents all of the major rock types in the EBL intrusion. These samples are being analysed for PGE, Au and selected trace elements in order to establish the potential for precious and base metal mineralization, and to understand the behavior of the PGE during, and subsequent to, the emplacement of the intrusion. Additional reconnaissance sampling was conducted on three small gabbroic bodies occurring to the north of the East Bull Lake intrusion. These bodies consist of fine- to medium-grained diabase/microgabbro and do not appear to be layered.

Intercumulus sulphides are present in trace amounts throughout the East Bull Lake intrusion, but to date, significant concentrations of sulphides have only been found in a basal anorthositic unit. Three distinctive styles of sulphide mineralization are recognized in this unit: Type 1 - disseminated to massive pyrrhotite + chalcopyrite ± pyrite occurring in a west-northwesterly-trending shear zone(s); Type 2 - minor concentrations of disseminated, intercumulus pyrrhotite + chalcopyrite developed in nodular anorthositic rocks. The nodular textures are defined by cm-sized, rounded or elliptical aggregates of plagioclase that are partially enclosed by interstitial pyroxene ± plagioclase; Type 3 - irregularly-distributed, disseminated pyrrhotite + chalcopyrite or pyrite within variably silicified and K-metasomatized anorthositic rocks. Anomalously high concentrations of Pt + Pd + Au (up to 5 ppm combined) are associated with both type 1 and 2 sulphide occurrences (E. Gallo, Gallo Exploration Services Incorporated, personal communication, 1990). No assay data are currently available for type 3 sulphide occurrences.

"FAST-TRACK" REPORT AND MAP PRODUCTION

Publication and Cartographic Services,
Ontario Geological Survey

The Ontario Geological Survey has revised the format of some of its publications, implementing new computerized publishing tools and streamlining its editorial processes. These changes are designed to help meet the demand for faster release of geoscience information while offsetting the ever-increasing costs of publication. As a result the appearance of OGS Reports, Studies and Maps has changed.

In development since the spring of 1989, these "fast-track" methods and standards make it possible to take a high-priority manuscript through the entire publication process in 6 months, subject to the availability of funds and personnel. During the first year of "fast-track" production, 10 reports totalling 1,297 typeset pages and including 8 full-colour maps were released. This work was carried out in parallel with the production the three annual summary volumes (totalling 897 typeset pages), 16 open file reports, 20 preliminary maps and 60 data files, and the beginning of work on the Geology of Ontario publication. A further 10 "fast-track" reports are scheduled for release by the end of 1990.

Production on this scale requires modern, efficient computer systems if deadlines are to be met and quality maintained at an acceptable level in the face of reduced staffing levels. New editorial and electronic publishing computer systems, which are now fully operational, enable the Survey to produce typeset reports in house for the first time. Acquired after an extensive consultant's study commissioned by the Ministry's Information Technology Section, it is expected that these systems will handle most of the Survey's publishing needs well into the 1990s.

One of the keys to the success of "fast-track" production is the Zed-Machine, a computerized colour separation system developed by a small Canadian firm with financial support from the OGS. Because software enhancements are being implemented on a regular basis, the system continues to keep the OGS in the forefront of digital colour map production.

Re-Os ISOTOPE CHEMISTRY OF THE CREIGHTON MINE, SUDBURY

Richardson, J.M., Dickin, A.P., Crocket, J.H., McNutt, R.H., Dept. of Geology, McMaster University, Hamilton, Ontario L8S 4M1 and Peredery, W.V. Inco Exploration and Technical Services, Copper Cliff, Ontario P0M 1N0. (* now at Geoscience Laboratories, Ontario Geological Survey, 77 Grenville St., Toronto, Ontario M7A 1W4)

^{187}Os is a decay product of the long-lived radioactive species ^{187}Re ($t_{1/2}$ = 42 Byr) and is also a platinum group element (PGE). Consequently, osmium isotope geochemistry is a powerful tracer to study the origin of PGE and other metallic ores. Osmium analysis presents major technical difficulties, in view of its resistance to normal thermal ionisation mass spectrometry. However, we have developed a procedure for precise Os isotope analysis (and elemental concentration determination) by ICP-MS. We have applied this method to a study of the geochemistry and petrogenesis of nickel sulphide ores from the Creighton Mine, Sudbury.

In the Creighton Mine, the Contact Sublayer of the Sudbury Intrusive Complex intrudes the Elsie Mt Greenstone Belt and the Creighton granite. The Fe-Ni-Cu-PGE sulphide ore contains xenoliths of the above rock types, plus exotic gabbroic and ultramafic inclusions. Pyrrhotite-pentlandite separates were extracted from massive footwall ore and disseminated sulphides from the Contact Sublayer norite.

Re-Os isotope data for seven samples, when plotted on an isochron diagram, define a linear array whose slope corresponds to an age of ca. 1850 Myr, the accepted time of intrusion of the Sudbury irruptive. Three other points lie below the isochron, probably due to later thermal disturbance of these samples. The regression yields an initial $^{187}Os/^{188}Os$ ratio of 0.600 $\pm$ 0.026 (2 sigma) which is far above the mantle Os isotope growth line at that time (187/188 = 1.04), and falls within error of the projected isotopic composition of Superior/Southern province basement. This shows that ore metals in the Creighton mine, and perhaps the whole Sudbury camp, are largely crustally-derived. Such a conclusion is consistent with the proposed meteorite origin of the Sudbury structure, which would be expected to cause wide-scale crustal melting. This would yield a silicic melt capable of mixing with, but not quenching, minor quantities of mantle-derived melt released by crustal rupturing.

QUALITY CONTROL FOR RARE-EARTH ELEMENTS IN GEOLOGICAL MATERIALS: COMPARISON OF XRF AND ICP-MS ZIRCONIUM DETERMINATIONS

Richardson, J.M., Doherty, W. and Tsigaris, J., Spectroscopy Subsection, Geoscience Laboratories, Ontario Geological Survey,

The rare earth elements (REE) are geologically important as they are economically and petrogenetically significant. However, due to the low abundances of REE in geological materials (0.001 - 10 ppm REE), the necessary precision and accuracy demanded by geologists cannot be met by solid sampling techniques such as X-ray fluorescence. Inductively coupled plasma-mass spectrometry (ICP-MS) has appropriate detection limits, but it requires that the sample be introduced as a liquid.

The insoluble nature of some REE-rich minerals, particularly zircon, results in a systematic low bias in REE determinations when conventional acid-based dissolution procedures are used. An alternative, reliable sample preparation procedure, lithium metaborate fusion followed by acid dissolution, is expensive and time consuming.

The Geoscience Laboratories compares Zr determinations done by XRF and ICP-MS to identify those samples in which a low bias occurs due to the incomplete dissolution of zircon in mineral acids. After consultation with the geologist as to the end-use of the data, identified samples can be reprepared by the acid fusion preparation technique can be used. This procedure results in precise, accurate data and the cost-effective use of resources within the Laboratories.

GEOSCIENCE LABORATORIES' LIMS

Rowell, D.J., Sudbury Advance Office
Ontario Geological Survey
Wong, P., Geoscience Laboratories
Ontario Geological Survey
Stoveken, J.,
BMB Compuscience Ltd.

The Geoscience Laboratories of the Ontario Geological Survey recently purchased a Laboratory Information Management System (LIMS) software package from BMB Compuscience Ltd. of Milton, Ontario.

The Laboratory Information Management System controls four main functions:

(1) Laboratory automation: includes the direct transfer of analytical results from dedicated analytical instrument computers to the laboratory system;
(2) Database management: the creation and maintenance of an historical analytical results database;
(3) Quality control management: the ability to segregate quality control results from regular data, and test these data sets using statistical routines for accuracy and precision, etc.;
(4) Laboratory administration: duties that must be completed to run or administer the lab efficiently: these duties include the production of analytical certificates, sample tracking and budget monitoring.

GEOLOGY OF THE SAVANT LAKE AREA

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The Savant Lake greenstone belt (SLGB) comprises dominantly metavolcanic and metasedimentary rocks and forms part of the Wabigoon Subprovince of the Superior Province of northwestern Ontario. Metavolcanic rocks include tholeiitic basalts of the Jutten volcanic group (JVG); intermediate pyroclastic rocks and flows of the Whimbrel Lake formation; and felsic to intermediate flows and pyroclastic rocks of the Handy Lake volcanic group (HLVG). Metasedimentary units include conglomeratic wackes and quartz arenites of the Jutten sedimentary sequence; polymictic conglomerates of the Savant Narrows formation; and feldspathic wackes, lithic wackes and magnetite +/- chert ironstone of the Savant sedimentary group. The SLGB is intruded by plutons of felsic to intermediate composition, and is bordered by foliated and gneissic granitoid rocks.

Two episodes of folding appear to have affected much of the SLGB; including the JVG, which historically has been interpreted as a northwest-facing sequence more than 10 000 m thick. Evidence of two folding events is provided by: 1) opposing structural facing directions throughout the supracrustal sequences; 2) outcrop-scale, refolded fold patterns; and 3) folds with axial surfaces and respective axial planar cleavages which strike both northward and eastward. Planar fabrics throughout the SLGB are generally associated with these two folding events, except in areas of increased strain intensity related to shearing.

The most prominent and laterally continuous zone of ductile deformation is the Kashaweogama Lake shear zone (KLSZ), where highly tectonized and altered rocks are exposed at least 45 km from Schist Lake in the west to the west-central shore of Savant Lake. The KLSZ strikes 070° to 080°, dips steeply northward, and possesses steep, down-dip mineral lineations that reveal south-side-down, dip-slip movement. Variably tectonized and altered (iron carbonate) rocks are observed at numerous other localities throughout the SLGB.

Mineral exploration in the area is for mesothermal gold and volcanogenic massive sulphide deposits. Gold is spatially associated with 070°- to 090°- striking shear zones with associated carbonate +\- silica alteration and quartz vein development (e.g., the KLSZ). Base metal exploration continues to focus on volcanic rocks of the HLVG in the southwest part of the SLGB. Hydrothermal alteration associated with base metal mineralization is indicated by the presence of secondary amphibole and aluminosilicate minerals such as staurolite, kyanite, andalusite and sillimanite.

PHANEROZOIC TECTONIC AND DEPOSITIONAL HISTORY OF ONTARIO.

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The Phanerozoic deposits in Ontario reflect a complex and subtle interplay between tectonically induced changes in the depositional environment and faunal evolution. These deposits were laid down on the interior of the North America craton over a series of arches and basins which had considerable influence on deposition. Arches were sediment sources and barriers to sediment migration during periods of upwarp and basins were sediment traps during downwarp. These structural features include the Michigan and Appalchian Basins and Algonquin and Frontenac Arches which affected sedimentation in southern Ontario and the Moose River and Hudson Bay Basins and Cape Henrietta Maria and Fraserdale Arches which affected sedimentation in northern Ontario. Basement warping associated with plate tectonic events beyond and within the Province established the local conditions of deposition by influencing factors such as water depth, salinity, current direction and terrigeneous transport.

During the Paleozoic, Ontario was covered with a series of inland seas which periodically inundated the craton. Deposits from these seas are now exposed as a succession of limestones, dolostones, shales and sandstones. Several periods of subaerial erosion have also been recorded which suggest the Phanerozoic rock record to be relatively incomplete. Mesozoic deposits in Ontario, are now largely restricted to the Hudson Platform and mostly reflect terrestrial deposition.

Analysis of the Phanerozoic tectonics and associated products suggest that the Phanerozoic sequence can be subdivided into 10 packages, here termed depositional cycles. Typically, a cycle reflects a period of transgression over the craton and starts with the deposition of a thin veneer of craton derived clastics. These rocks are overlain by units which are carbonates or clastics depending on the input of terrigenous sediments into the area. Commonly, a cycle is terminated by uplift causing regression and a hiatus or causing restriction in circulation and the deposition of evaporites.

SUMMARY OF MINING/EXPLORATION ACTIVITY 1990 THE TIMMINS RESIDENT GEOLOGIST'S AREA

Sangster, P.J., Timmins Resident Geologist's Office, Mines and Minerals Division, Northeastern Region.

Since its inception in 1946, The Timmins Resident Geologist's Office has provided a service to all facets of the mining / exploration industry and to other government agencies. The nature of these services has changed in response to changes in the industry. Ongoing surveys by the Resident Geologist's Office provide an up-to-date picture of the status of mining in the area taking into account the many challenges facing the industry in the 1990's. The current activities in the Porcupine Mining Division are presented not in isolation but in the context of over eighty years of recorded exploration, development and mining history.

RUTILE, TITANITE AND MONAZITE IN THE POST-ORE ALTERATION ZONE OF MASSIVE SULFIDE DEPOSITS IN THE SUPERIOR PROVINCE, ONTARIO: A POTENTIAL TOOL FOR GEOCHRONOLOGY.

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A comparative study of alteration assemblages associated with five massive sulfide occurrences in the Superior province demonstrates the differences and similarities between the deposits. The study area include the Geco, Winston Lake, Mattabi, Lyon Lake and the Kidd Creek mines. All of the deposits show evidence of a late metamorphic-metasomatic overprint on mineralized rocks, and metamorphic grade ranges from greenschist (Kidd Creek, Mattabi, Lyon Lake) to amphibolite facies (Geco, Winston Lake).

In the lower grade rocks, relict texture and the 'primary' alteration assemblage associated with ore deposition is partly preserved, whereas in the high grade rocks, metamorphic overprint destroyed these primary features. In the low grade alteration assemblage (late sericite, chlorite) rutile is the titanium-bearing phase associated with the hydrothermal overprint, and in the high grade assemblage (late biotite, anthophyllite, chlorite), it is titanite. Close textural association of rutile with monazite in chlorite and biotite at some deposits suggests the co-precipitation of these minerals from a common fluid, and therefore the remobilization of REE's during late hydrothermal alteration. Rutile, titanite and monazite are suitable for U-Pb geochronology, and thus can be used as a potential tool for dating the hydrothermal overprint at the above deposits.

Some remobilization of the ores also took place during this late hydrothermal episode at all five localities. Most extensive remobilization was noted at Geco mine, where the aboundance of subrounded zircons (probably detrital) in the rocks suggests a large sedimentary component in the deposit.

STRUCTURAL GEOLOGY OF THE WESTERN BEARDMORE-GERALDTON BELT

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The Beardmore gold camp, within Eva and Summers townships, is at the western end of the Beardmore-Geraldton Belt (BGB), a transitional supracrustal sequence between the Quetico and Wabigoon subprovinces of northwestern Ontario. The BGB, formerly known as the Sturgeon River gold belt, consists of three metavolcanic and three clastic-rich metasedimentary sequences, each of which is narrow (≤10 km thick), trends eastward and is subparallel to the strike of the main belt. Gold production from the BGB exceeded 4 million ounces, nearly ¼ of which was produced from the Beardmore camp. Recent discoveries of fault-zone-hosted gold mineralization elsewhere in the BGB has lead, in general, to a re-evaluation of the BGB and specifically, to a detailed litho-structural re-mapping of Eva and Summers townships.

A proximal volcanic facies, characterized by rapid variations in rock type, was delineated in north-central Summers Township. Here, tuffs are interfingered with coarse metavolcanic fragmental rocks. Felsic fragments, some pumiceous, are conspicuous within an assemblage of fine lapilli-sized mafic to intermediate fragments. Some mafic fragments bear pale reaction rims, presumably caused by incipient reaction with a hot matrix. The heterolithic character and poor sorting of the fragments have the earmarks of pyroclastic flow deposits.

Bedding planes are steeply dipping, commonly overturned and strike east-northeast or northeast. The cleavage is commonly subparallel to lenticular bedding; features typical of bedding transposition. The boundaries between metavolcanic and metasedimentary belts are commonly faulted as indicated by the dextral strike separation of Proterozoic diabase dikes. Some fault zone rocks display strong silicification and Fe-carbonate alteration.

Narrow (≤1 km thick) linear zones of overturned, south-facing strata suggest the presence of regional stratigraphic top reversals within the southern BGB. Local younging directions as well as the angular discordance of stratigraphic horizons across a locally unfaulted contact seem to indicate a south-facing unconformity between the central metavolcanic and southern metasedimentary belts. The regional top reversals may be due to 1) stratigraphic inversion of panels of rock within an imbricate thrust wedge or 2) large-scale high-amplitude folding. The hypothetical hinge zones of the oppositely facing panels are unfaulted, an observation consistent with the latter interpretation. The pattern of overturned beds is consistent with either a train of upright eastward-trending folds which have elastica style or else with upright refolding of early recumbent folds.

DEFORMATION AND AURIFEROUS QUARTZ VEINING IN KEITH TOWNSHIP, NORTHERN SWAYZE BELT

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The displayed map shows the geology of an area exposed by recent stripping about 1.5 km along strike southeast of the Joburke mine (Keith Township), a past producer of 512 kg of gold. In the summer of 1990, this area was mapped by the Ontario Geological Survey as it is the largest exposure of a deformation zone which is mainly covered by overburden. This zone, here referred to as the Keith-Penhorwood deformation zone (KPZ), is principally characterized by abundant carbonatization and dominantly ductile shearing.

The KPZ extends west of the map-area, at least as far as the Joburke mine. East of the map-area, it is exposed close to the boundary of Keith and Penhorwood townships, and in the Jehann Lake area of north-central Penhorwood Township. Hence, the KPZ has an apparent strike-length of at least 12 km. Its total width is unknown. Field data from the map-area, and other localities, suggest that the KPZ consists of a central subzone of higher strain and carbonatization up to about 90 m in width, flanked by similar, but narrower, outer deformation subzones. At the large scale, the KPZ has an easterly trend, but the trend is variable due to gentle megascopic flexures.

The map-area includes the (old) Hoodoo prospect and the Patricia showing, the site of 1987 gold discovery. The map-area represents a short segment of the KPZ characterized by simple lithology and complex structure. It is underlain by variably deformed and carbonatized tholeiitic basalt intruded by pre- or syn-tectonic dikes of felsic porphyry. The basalt is host to quartz-carbonate veins, some of which are sulphide-bearing (pyrite, chalcopyrite) and auriferous. Most of these veins are associated with localized mesoscopic folds and complex plications which resulted from ductility contrast between basalt and porphyry dikes.

The lithological and structural features of the map-area represent a set of specific conditions that resulted in gold mineralization, and other potentially favourable conditions may occur along the KPZ. Readers interested in further information about the map-area and the KPZ are referred to the 1990 Summary of Field Work, Project 88-06.

HYDROGEOLOGIC IMPLICATIONS OF BURIED ESKERS IN ESSEX COUNTY, ONTARIO

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The main objective of this study is to determine the hydrogeologic significance of eskers buried within the low permeability clayey overburden of Essex County, Ontario. These buried eskers, identified by Morris (1988, 1989) by analyzing water well records, remote sensing, and follow-up drilling; are coincident with anomalously young groundwaters in the underlying aquifer. The aquifer has been thought to be well-confined beneath >30 m of clayey overburden. We hypothesize that the buried eskers have resulted in enhanced fracturing of the clayey aquitard which in turn facilitates localized recharge to the underlying aquifer. To date, we have examined the overburden geology and installed groundwater monitoring wells in three transects across a target esker in Rochester Township. We are analyzing selected groundwater samples from the well network for their oxygen-18, deuterium, tritium, and carbon-14 contents in order to determine the groundwater age distributions both across and along the feature. We are also evaluating hydraulic conductivities and hydraulic gradients at each transect to establish groundwater flow directions and rates.

SALINA GROUP: RELATION TO SALT CAVERNS, REEF RESERVOIRS AND INDUSTRIAL MINERALS, SOUTHWESTERN ONTARIO

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The Salina Group of Late Silurian age is a succession of dolostone, anhydrite and salt units. The lowermost rocks, the "A" unit, is intimately related in depositional history and environments to the Guelph Formation reef bioherm reservoirs, which it encloses. The overlying Salina units, "B" to "G", are more regional in extent and each is lithically consistent.

The Salina Group, in the southwestern Ontario subsurface, has its outcrop erosional edge along a line from the Bruce Peninsula to the Niagara River. It thickens to about 450 metres near Sarnia, where its salt units total over 200 metres in thickness. Substantial halite also underlies the area southeast of Lake Huron and near Windsor. Gypsum is present at surface just southwest of the erosional edge (Project #319: S. Haynes).

Cores through the base of the Salina "A" unit in the area between pinnacle reef bioherms have a well-developed breccia soil at the top of the Goat Island Member of the Lockport Formation. The Guelph Formation is not present in the inter-reef area. The subaerial paleokarst unit is overlain by the shallow transgressive succession at the base of the Salina Group.

The Salina suffered regional differential erosion, especially of halite. This shows various times and styles of paleo-groundwater flow, starting in Lower Salina time.

Halite is the principal cement in tectonic fractures in Guelph reef bioherms. It appears to have come from the "B" salt unit, and to have maintained the reservoir seal while occluding some of the earlier porosity.

Regional thinning in the Salina Group is due to 1) the loss of halite from within the section, and 2) regional thinning of the entire Salina section from the top down. This requires re-evaluation of the history of the Algonquin Arch.

The Salina Group has considerable economic and environmental importance. It yields halite from mines and brine wells, and gypsum from quarries. Caverns in halite units are used to store liquid hydrocarbons and are available for waste disposal.

GEOLOGY OF THE RED LAKE AND VARVECLAY-FAVOURABLE-WHITELOON AREAS, NORTHWEST ONTARIO

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The Red Lake and Varveclay-Favourable-Whiteloon areas straddle south and northeast margins of the Berens River Subprovince in Ontario. At these localities felsic plutonic rocks, which underlie most of the Berens River Subprovince, are in contact with the Red Lake and Favourable Lake greenstone belts, respectively. The new mapping shows irregular to lobate sodic and potassic batholiths that intrude the Red Lake greenstone belt. Although brittle fractures are common in most outcrops, few major ductile shear zones are identified in the felsic intrusions or at the north margin of the Red Lake greenstone belt. Several small metavolcanic and metasedimentary units are defined in the batholithic areas.

Geology of the southern Sachigo Subprovince, which lies northeast of the Berens, is dominated by large oval granite batholiths. The batholiths are separated by belts of sodic intrusive rocks and the Favourable Lake greenstone belt that extends from the Manitoba border more than 100 km southeast near Varveclay, Favourable and Whiteloon Lakes. The west end of the Favourable Lake greenstone belt is made up of highly deformed and metamorphosed mafic metavolcanic flows, intermediate fragmental rocks and clastic metasediments. Quartz arenite and marble units indicate that part of the belt originated as an early platform sequence. Two-mica granites, thought to be derived by anatexis of sediments, occur at edges of the greenstone belt. The northern Berens River Subprovince is underlain by an elongate granite batholith and irregular units of sodic intrusive rocks and gneisses. The dextral transcurrent Bear Head fault comprises a zone of mylonite that is developed locally along the subprovince boundary. At its southeast end near North Spirit Lake, the Bear Head fault curves east into the Sachigo Subprovince.

THE TECTONIC ASSEMBLAGE MAP OF ONTARIO

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The newly designed Tectonic Assemblage Map of Ontario illustrates the geology of the province from a new perspective. Its principal function is to display, through compilation and interpretation, the subdivision of lithostratigraphic successions into tectonic assemblages and the grouping of some of the intrusive complexes into plutonic suites. It also displays volcanic centres, structural features, and sample locations of U/Pb isotopic age determinations on zircons in magmatic units.

A **tectonic assemblage** is composed of stratified rock units that developed in a common depositional or tectonic setting during a discrete interval of time and is typically bounded by faults or unconformities. Assemblages can be subdivided into one or more groups or formations; the identification of tectonic assemblages in Precambrian rocks, particularly through the aid of field geology and geochronology, constitutes the first stage in the process of formal stratigraphic mapping. A **plutonic suite** comprises a set of plutons of common age, composition and probably common origin that are spatially associated and occur in a common tectonic environment. A new geochronometric subdivision for the Precambrian and a subdivision of Phanerozoic time into tectonic cycles, adopted for this map, will permit the map-user to visually identify patterns of ages for assemblages and plutonic suites across the province.

This map forms part of the folio of geological and geophysical maps of Ontario being produced at a scale of 1:1 000 000. It is accompanied by charts that summarize the main magmatic, sedimentary, structural and tectonic events recorded in the bedrock of Ontario. The charts complement the map by permitting regional correlation and interpretation of tectonic events. They also illustrate, for example, the episodicity of volcanic and plutonic activity more explicitly than is possible on the map.

Examples of parts of the Tectonic Assemblage Map illustrate the value of the map to researchers and mineral explorationists. We believe this type of map has many exploration applications; one can use this map to develop more detailed stratigraphic correlations and, in future, relate the distribution of different mineral deposit types to the environments of tectonic assemblages and their boundaries.

EXPLORATION AND DEVELOPMENT ACTIVITIES IN THE WAWA AREA, 1990

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Exploration and mine development activity in the Wawa District occurred primarily in five main areas: 1) the Renabie-Dog Lake area, 2) the Goudreau-Lochalsh area, 3) the Wawa-Michipicoten area, 4) the Mishibishu Lake greenstone belt, and 5) the Kabinakagami Lake and Dayohessarah Lake greenstone belts in the northern part of the district. Exploration activity continued to decrease in terms of the number of exploration companies active, the number of work permits, the length of exploration projects, and the number of clients using the Wawa Resident Geologist's Office. This decrease is due to factors such as the decrease in the price of gold, changes to Federal exploration incentives, and the onset of recessionary pressures.

In the Goudreau area, Canamax Resources Inc. continued with the underground development of the Lochalsh Deposit, and gained access to the mineralized zone prior to suspending operations in the fall due to the decreasing gold price. The Kremzar mine suspended operations in October. The nearby Magino Mine (Muscocho Explorations Ltd.) is continuing to operate. Spirit Lake Exploration continued diamond drilling and evaluating the gold reserve on the Edwards property. Corona Corp. continued an exploration program on 13.5 townships leased from the Algoma Central Railway in the Goudreau and Iron Lake areas. New gold-bearing zones related to zones of high strain were identified in both areas.

In the Wawa area, Algoma Steel Corporation's Ore Division ceased underground development activities. Underground production, ore preparation, and sintering will continue until 1992, at which time operations are to be shut down unless an alternative, limited operation proves feasible. Citadel Gold Mines Inc. initiated a surface exploration program on its properites south of the Surluga Mine which Citadel continued to dewater. Test mining and milling indicate that a substantial rise in the price of gold is required before the mine is economic. Citadel has a mill on site and is interested in using the facility as a custom mill. Van Ollie Explorations Limited continued exploration on property immediately east of the Citadel ground.

In the Mishibishu Lake area, the Magnacon Mine experienced operational difficulties that, together with the decreasing price of gold and other factors, resulted in a suspension of underground operations in the fall. At Noranda's Eagle River project, underground development and test stoping were completed with favourable results. A production decision is expected soon. Exploration on the Denison Lake Project (Central Crude Ltd./ Joutel Resources Ltd.) resulted in the delineation of a gold-bearing quartz vein system over a strike length of about one kilometer.

GOLD METALLOGENY ALONG THE DESTOR PORCUPINE DEFORMATION ZONE EAST OF MATHESON

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During the 1989-1990 field seasons, geological mapping was focused in Hislop, Guibord, Michaud and Garrison townships, an area to the east of Matheson through which the Destor Porcupine deformation zone (DPDZ) directly passes. The purpose of the project was to determine the extent and nature of areas of high strain related to the DPDZ, and to use these characteristics together with metamorphic and alteration data to further constrain the location and timing of gold mineralization here.

Early workers in the area defined the position of the Destor Porcupine (DP) 'fault zone' or 'break' by a distinct change in facing directions, best evidenced by pillow orientations in basaltic sequences. This feature has been noted across other Archean deformation zones in Ontario and elsewhere. Close to the 'break', facing directions can become more erratic, and tight isoclinal folding is indicated in some instances. This is complicated by the 'melange' of lithologies commonly found in the DPDZ, generally consisting of altered ultramafic rocks, Porcupine and/or Timiskaming sedimentary rocks plus felsic intrusions, for which facing indicators may be rare or entirely absent. Furthermore, field work to date indicates that a much more extensive zone of deformation may exist about the DP 'Break', such that the traditionally perceived position of the main 'fault zone' may be but one component of the DPDZ. Zones of high strain that comprise the DPDZ can be broadly subdivided into two principal orientations, consisting of 070° striking and 110° striking segments. Deformation within the DPDZ is dominantly brittle, and few kinematic indicators are available. North to northeasterly striking cross faults commonly produce significant lithological and structural truncations (evident on aeromagnetic maps), and are often marked by Matachewan diabase dikes in the west half of the area. The intersection of these faults into the DPDZ often coincides with areas of significant gold mineralization.

Granitoid intrusions are of two main types: (1) calc-alkaline quartz bearing and (2) alkaline quartz poor. The calc-alkaline suite appears older, and are cut by syenitic phases. Many of the intrusions are tightly confined within a network of high strain zones comprising the DPDZ. Amphibolitic contact aureoles are variable width are present around some intrusions, while their absense is indicative of fault contacts with country rocks for others. Lamprophyre dikes are common in the region, but they appear to be more strongly concentrated in areas of gold mineralization. These dikes are often deformed and weakly mineralized and appear to post-date the syenite intrusions which may also host gold ore.

Gold mineralization is hosted by all lithologies represented in the area except diabase, and most often occurs at or near the contact of rheologically distinct units. Virtually all gold mineralization in the area is quartz ± carbonate vein and fracture controlled, and their orientations generally mimic that of the DPDZ. Specular hematite alteration is widespread, especially in association with syenite, while ankeritic carbonate, sericite, green mica and anhydrite alteration are typically common in association with gold. The Buffonta deposit, which occurs within an intrusion contact aureole, departs somewhat from these characteristics. Fracture controlled mineralization post-dates a metamorphic calc-silicate alteration, but the significance of this timing difference remains unresolved.

To date, over 40 occurrences of gold mineralization are documented in this area, but only the recently closed Ross Mine has been a prolific producer (>1 million ounces). The overall distribution of gold deposits and occurences in the area suggests a strong spatial association with the DPDZ. However, no deposits occur directly in the main 'break'. Because of the overall low bedrock exposure, the excellent accessibility, and the positioning of the area between the Timmins gold camp to the west and the Harker-Holloway gold camp to the east, this area is considered to have high potential for undiscovered economic gold mineralization.

ECONOMIC GEOLOGY AND GEOCHEMISTRY OF GRENVILLE CARBONATE ROCKS

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Metamorphosed carbonate and calc-silicate sedimentary rocks underlie much of the Central Metasedimentary Belt of the Grenville Province in southeastern Ontario. These economically-important marbles are mined to produce dimension stone, decorative aggregate, crushed and ground rock for mineral filler and other applications, talc, and magnesium metal. They also have potential for producing graphite, wollastonite, and zinc.

A set of four marble-related data files intended for analysis on personal computers, have been prepared for release on floppy disk as an Open File Report. Two data files contain whole rock and trace element geochemical analyses and sample locations for 1912 samples which were collected across the marble belts, and another file contains sample descriptions, including mineralogy ("impurities"). These geochemical and sample description data were previously published in paper form by Grant et al (1989). The fourth data file, prepared by H.D. Meyn, MNDM's Regional Specialist and his staff, contains quite detailed information about 636 mineral occurrences which occur within Grenville marbles.

The data can be used with a personal computer to plot the spatial relationships between, for example, known occurrences of graphite, and graphite-bearing samples in the rock sample data set. The locations of rock samples with a specific composition can be plotted on a map together with, for example, known occurrences of zinc and the locations of rock samples which are anomalous in zinc. Data subsets such as data from individual marble belts can be examined. Within some areas the sample distribution is dense enough to allow a reasonable attempt at contouring. An example is contouring of silica values to identify areas of low-silica marble which might be valuable for producing mineral fillers.

Computer analysis of the marble-related data is an ongoing project in MNDM's Southeastern District, and potentially economic marble areas which are suggested by this work will be examined in the field during 1991. The data have been prepared on floppy disk for Open File release, so that prospectors and the exploration industry may use them now.

REFERENCE

Grant, W.T., Papertzian, V.C., and Kingston, P.W. 1989. Geochemistry of Grenville marble in southeastern Ontario; Ontario Geological Survey, Mineral Deposits Circular 28, 266 p.

Robotized Sample Preparation for X-Ray Fluorescence Analysis.

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X-ray fluorescence (XRF) has long been used to provide the "major element" (Si, Ti, Al, Ca, Mg, Mn, K, P, Fe) composition of rocks. The Geoscience Laboratories of the OGS has been analyzing samples like this for many years. Samples can be from geologists, prospectors or mining companies and the data used to define and classify Ontario rock units.

Because automated operations can provide a high level of safety, save time and money and decrease the cost of consumables, such an approach to XRF sample production was developed with the installation of Leco Instruments Ltd. automated FX200 fluxer. The fluxer can automatically prepare 6 samples at a time and produce 75 glass disks a day. This is an 100% improvement over the manual method used previously. Sample size and thus necessary reagents was decreased by 25%, a important cost savings.

Preprogrammed options are easily selectable and provide operational flexibility, save time and eliminate un necessary procedures. There is a manual operation mode to allow the definition of parameters for use with the automatic mode and the flexibility to process atypical samples. The fluxer also features operator selection of the number of burners used which lowers fuel costs, automatic burner ignition and crucible protectors. The fluxer has diagnostic programming built in which informs the operator if certain conditions are not met (e.g. event of power failure).

Samples are swirled during fusion by an unique agitation system that results in complete homogeneity in the melt and provides higher quality disks than those produced by other methods. This feature is especially important in the analysis of geological material containing minerals such as zircon, chromite, cassiterite and other refractory phases. Thus the quality of the samples prepared is consistently homogenous and defect-free. Automatic sample preparation allows the Geoscience Laboratories greater efficiency, reproducibility, increased productivity and cost-effectiveness in the preparation of XRF samples.

MINERALOGICAL AND ISOTOPIC STUDIES OF DIAGENESIS IN CAMBRO-ORDOVICIAN SEDIMENTARY ROCKS, SOUTHWESTERN ONTARIO

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The stratigraphic position of Cambrian Mt. Simon/Eau Claire and Ordovician Shadow Lake Formation sedimentary rocks in southwestern Ontario provides an opportunity to examine the diagenetic effects of several potential fluids including Precambrian basement brines, connate (sea?) water and meteoric water. The rocks can be subdivided into quartz-dominated and carbonate (mainly dolomite)-dominated assemblages. The <2 μm (clay) size fraction in the quartz-dominated samples contains K-feldspar, 10Å clay minerals (illite, mica) and minor amounts of 14Å clay (chlorite). Carbonate-dominated samples contain dolomite ± calcite, K-feldspar, 10Å (illitic) clays and a smectitic clay in the same size fraction. Textural evidence supports the following paragenetic sequence: K-feldspar overgrowths (± authigenic K-feldspar), quartz overgrowths (+ some authigenic K-feldspar), grain coating clay, early calcite, dolomite, late calcite.

Feldspar in these rocks is almost exclusively potassic. It occurs as detrital grains, upon which abundant overgrowths have developed, as euhedral authigenic crystals, and in the matrix. Authigenic phases are enriched in K and depleted in Ba and Na relative to their detrital equivalents. Widespread potassic alteration has been recognized elsewhere in midcontinental North America. The possibility exists that similar, if not the same formation waters may have entered the Cambrian section of southwestern Ontario. Dolomite is the most common carbonate mineral. It occurs as chemically (Fe, Mn) zoned rhombs within pores, as a replacement of K-feldspar and as a massive pore-filler. Calcite occurs as scattered inclusions within dolomite, as cores to dolomite rhombs, and as a massive pore-filler. Where dolomite is the only carbonate phase (Cambrian samples), oxygen isotopic compositions define a narrow range, $\delta^{18}O = -6.5 \pm 0.7‰$ (PDB), compatible with other lower Paleozoic dolomites. $^{87}Sr/^{86}Sr$ ratios for the same dolomites average 0.70926 ±0.00017, similar to the accepted value for Cambrian seawater. $\delta^{18}O$ values for dolomite-calcite pairs are both higher and lower than the "dolomite-only" values. $\Delta^{18}O$ ranges from +1 to +9‰. Within-core variability in $\delta^{18}O$ of the pairs can be explained by permeability differences related to rock type. Sandier units have lower $\delta^{18}O$ than carbonate-dominated units, suggesting greater penetration of the former by meteoric water. $^{87}Sr/^{86}Sr$ ratios for calcite-dolomite mixtures suggest that calcite values are lower than coexisting dolomites. One explanation is that the calcite was precipitated from seawater at a later time. Carbon isotopic compositions for both carbonate phases are variable but within a single core decrease with depth.

Isotopic evidence supports at least two types of diagenetic fluids. Dolostones which are all from the lowest parts of the Cambrian sequence, have $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ values compatible with derivation from Cambrian seawater. Calcite-dolomite pairs from upper parts of the Cambrian sequence and from Ordovician samples have $\delta^{18}O$ compositions which bracket the dolostones. Lower values suggest alteration by meteoric water while higher values may represent the influence of more recent seawater (brine?). $^{87}Sr/^{86}Sr$ values are consistent with this interpretation.

THE MANITOUWADGE- HORNEPAYNE REGION: A NEW GEOLOGICAL MAP

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The preliminary map documents the results of a two-year regional reconnaissance mapping program and compilation of previous work.

Across the central portion of the region a nearly continuous supracrustal assemblage occurs along the northern boundary of the Wawa Subprovince. It is composed of folded and metamorphosed mafic to felsic volcanic, layered mafic intrusive, and sedimentary rocks, of up to 2 km tectonised thickness. To the north, highly strained metasedimentary migmatite and granulite units, originally greywacke turbidite, predominate in the Quetico Subprovince. The contact between these metasedimentary rocks and the assemblage of east-trending, mixed volcanic and metasedimentary supracrustal rocks is generally obliterated by foliated to gneissose intrusive tonalite-granodiorite sheets. Mildly deformed, massive dioritic to ultramafic plutons and spatially associated, undeformed breccia bodies occur adjacent to the supracrustal unit. Within much of the southern portion of the region, a domical mass of foliated to gneissic tonalite to granodiorite, the Black-Pic Batholith, abuts and structurally underlies the supracrustal rocks to the north.

Considerable interest in the supracrustal rocks followed the discovery in them of massive sulphide deposits in the Manitouwadge area. The supracrustal rocks sporadically enclose kilometre-thick layered mafic intrusions that contain anorthositic to ultramafic layers. These supracrustal and intrusive rocks have now been traced eastwards by us, as far as Hornepayne, both as a semi-continuous unit and as trails of enclaves within tonalite. The supracrustal rocks have a regional easterly trend, modified by a series of northeasterly trending asymmetrical folds.

Mineral potential in the region continues to be influenced by the presence of massive sulphide deposits spatially associated with the mutual contact of mafic and felsic volcanic units within the thicker portions of the supracrustal belt. We suspect there is potential for Pt mineralization within ultramafic portions of the diorite suite and for Ni-Cr within ultramafic portions of the layered mafic intrusions.

GEOLOGY AND EXPLORATION POTENTIAL OF THE KABINAKAGAMI LAKE GREENSTONE BELT

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The Kabinakagami Lake greenstone belt mapping program concluded in 1990. The map area is located approximately 100 km north-northeast of Wawa and includes the contiguous townships of Lipton, Derry, Lizar, Ermine and Hawkins. The greenstone belt continues to the southwest beyond the map area.

Mafic to intermediate metavolcanic rocks containing narrow interbeds of intermediate to felsic metavolcanic rocks are the dominant lithologies in the greenstone belt. Clastic metasedimentary rocks outcrop on the southeastern shore of the lake. The supracrustal rocks are intruded by granodioritic to trondhjemitic sills and plugs. All units are cut by a series of late, southeast-trending diabase dikes.

Two mines within the belt have recorded gold production. The Shenango Gold Mine (1935-1941) and the Hiawatha Gold Mine (1936-1939) were low grade, very low tonnage operations. Encouraging assay results from a number of mineral showings in the greenstone belt suggest that the greenstone belt is a potential target for gold exploration.

All of the known mineral occurrences are either within a moderately sheared zone, lying along the steeply-dipping, northeast-trending Bear Creek Fault in Lizar Township, or along a strongly sheared, steeply dipping, eastward-trending contact between mafic metavolcanic rocks and a tonalitic intrusion in central Hawkins Township. Quartz veins are a prominent feature in all of the known gold occurrences.

In Lizar Township, the shear zone is occupied by a granodioritic to trondhjemitic sill. Gold bearing quartz veins are associated with the margins of the sill or with quartz porphyry sills in mafic metavolcanic rocks in the shear zone. A shear zone with associated granodioritic sills has been reported to lie along the southwest extension of the Bear Creek fault zone in Nameigos Township.

In Hawkins Township, the gold showings occur in quartz veins at the strongly sheared contact between mafic metavolcanic rocks and a tonalitic intrusion. This shear zone (Puskata Lake shear zone) is a steeply dipping, dextral, transcurrent structure that bounds the south side of the Kabinakagami Lake greenstone belt (Leclair 1990). The known mineralization along the southwestern portion of the shear zone is usually associated with quartz segregations in fractured and mylonitic metavolcanic rocks.

GEOSCIENCE LABORATORIES ANALYTICAL CAPABILITIES AND METHODS

Priscilla Wong, Geoscience Laboratories, Ontario Geological Survey

The Geoscience Laboratories provide elemental and mineralogical whole-rock analytical capabilities in support of the programs of the Ontario Geological Survey and external clients. Capabilities include sample preparation, mineral separation and identification, grain size analysis, and quantitative analytical capabilities. As an integral part of these services and in response to the changing demands of the client group, development work is performed to improve precision and accuracy as well as lower the determination limits of the methods.

The Mineral Science Subsection primarily provides the following services: determinative mineralogy, comminution of samples, mineral separation, grain size analysis, thin and polished section preparation, and fire assaying. Preliminary visual examination and X-ray diffraction identification of mineralization in hand samples is routinely performed for clients.

The Spectroscopy and Chemistry subsections provide quantitative and qualitative elemental analysis using a variety of instrumental techniques. Of the 87 naturally occurring elements, 71 of them can be determined by the laboratory. Methods have been developed which are suitable for a wide range of clients including those who are involved in petrogenetic studies or economic mineral exploration. The instrumental techniques available to OGS clients include: X-ray fluorescence spectrometry, inductively coupled plasma optical emission spectrometry, inductively coupled plasma mass spectrometry and atomic absorption spectrometry. The use of roboticized sample preparation is currently being investigated for application in trace elemental analysis.

The capabilities of the Geoscience Laboratories are published in the "Analytical Capabilities and Services" guide. The methods used to perform analytical work are reported in "The Analysis of Geological Materials. Volume II: A Manual of Methods".